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# MACHINE DESIGN

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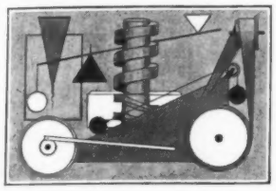
ENGINEERING–PRODUCTION–SALES

Volume 1 | November, 1929 | Number 3

## *Next* MONTH

*CONFLICTING information has appeared from time to time on the subject of linestart motors —their advantages, disadvantages and general characteristics, serving only to confuse the subject in the minds of chief engineers and designers. With the object of attempting to clear up this confusion, Machine Design will publish in the next issue an article written specifically for this purpose.*

*The concluding portion of the current article by Chapin Hoskins also will be given in the next issue. This contribution covers the methods employed by various companies in putting to the best possible use all data collected from the field.*

L. E. Jermy.

*Managing Editor*

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MACHINE DESIGN
November 1929

# Designing Drive and Control for 600-Ton Hangar Doors

By Wilbur J. Watson
*Wilbur Watson & Associates, Cleveland*

LAYING of the master ring of the ZRS-4 on Nov. 7 at Akron, O., not only marks the fruition of dreams for an American dirigible industry on a large scale, but also focuses attention on the manufacturing and docking facilities provided by the Goodyear-Zeppelin Corp. for constructing and housing the two airships being built by this company for the United States navy.

The building is approximately semi-paraboloid in shape, 1175 feet long, 325 feet wide and 211 feet high. The floor area of 364,000 square feet is much the largest single uninterrupted space covered to this time by a single structure.

Most unusual in this building are the spherical doors, with their hinges and supporting trucks and the operating mechanism for opening and closing them.

If one can visualize a quarter of a half of an orange peel set up on a flat surface, held with a pin at its pointed top and resting on a set of rollers distributed under the bottom edge, and imagine this one-eighth of an orange peel as 202 feet high, 214 feet wide at the bottom, fastened or hinged at the top point with a huge

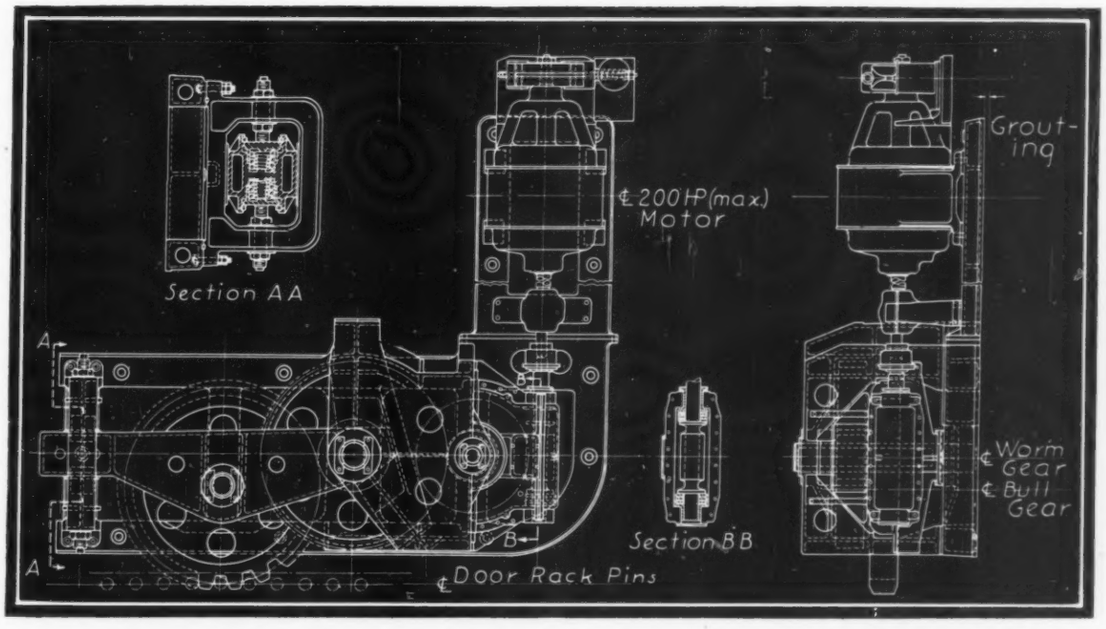



*Fig. 1—Plan, end elevation and a section of door-moving mechanism. Section AA shows spring device for preventing excessive binding of bull gear and pins*

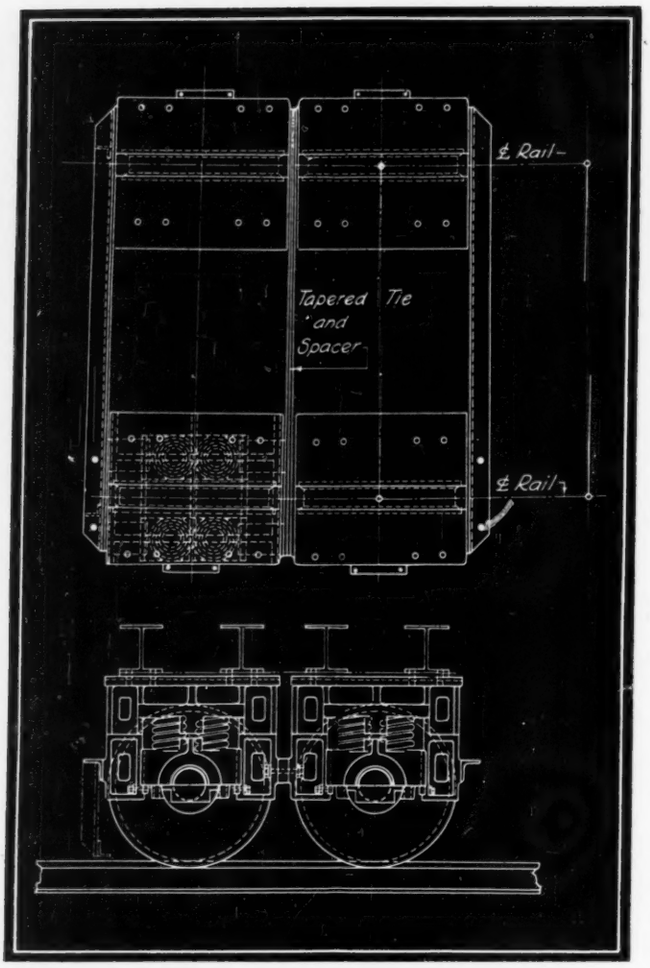



*Fig. 2—Drawing of door truck showing tapered spacer to allow for curvature of rails*

hollow forged pin and resting on 40 wheels at its base, he would have an idea of what one leaf of two that close one end of the hangar is like.

Not considering the snow that may accumulate on the doors or the wind pressure against them, the doors alone weigh about 600 tons for each leaf or 1200 tons for each end of the building.

Obviously the simplest way to mount this heavy leaf so that it can be moved back and forth is on wheels running on a track, similar to railroad equipment. In this case, 40 forged steel, double-flanged wheels, 27 inches in diameter, running on the two rails, weighing 100 pounds per yard each, set to the standard railroad gauge, are used under each leaf of the doors.

### Each Wheel Has Individual Axle

The wheels are spaced almost uniformly in pairs under the long curved structural steel sill which constitutes the base of the door. As shown in Fig. 2, each pair of wheels is set radially so as not to bind against the curved rails which form the track, but each wheel is mounted on a separate short axle so that slipping caused by mounting two wheels on one axle is avoided.

Because it is not practicable to so build a large structure of this nature that the weight will be equally divided on all of the 40 wheels, each wheel is separately mounted under bearing boxes which rest against heavy springs. Therefore, if one wheel receives more weight than its neighbor, its springs will give more until the weight is more evenly distributed.

The hinge pins to fasten the top points of the doors to the main shell of the building are secured by heavy steel frames to the roof girders and a separate pin for each leaf of door is provided. Each pin is required to resist the side pressure against it caused by the door tending to fall inward, but it does not need to carry any vertical weight because the door is horizontal at the top where it bears against the pin, except when a strong wind blowing through the building (with doors on other end open) is of sufficient strength to tip it backwards, at which time the pin is required to hold the door from being blown out.

The pin cannot be regarded as being always

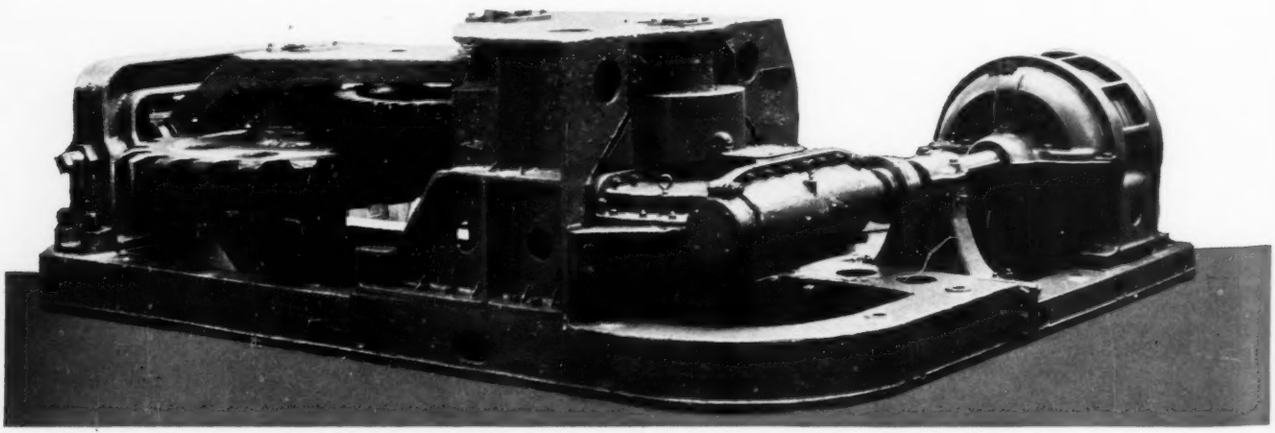


*Fig. 3—This view of driving mechanism shows relative position of motor, intermediate and final gears*

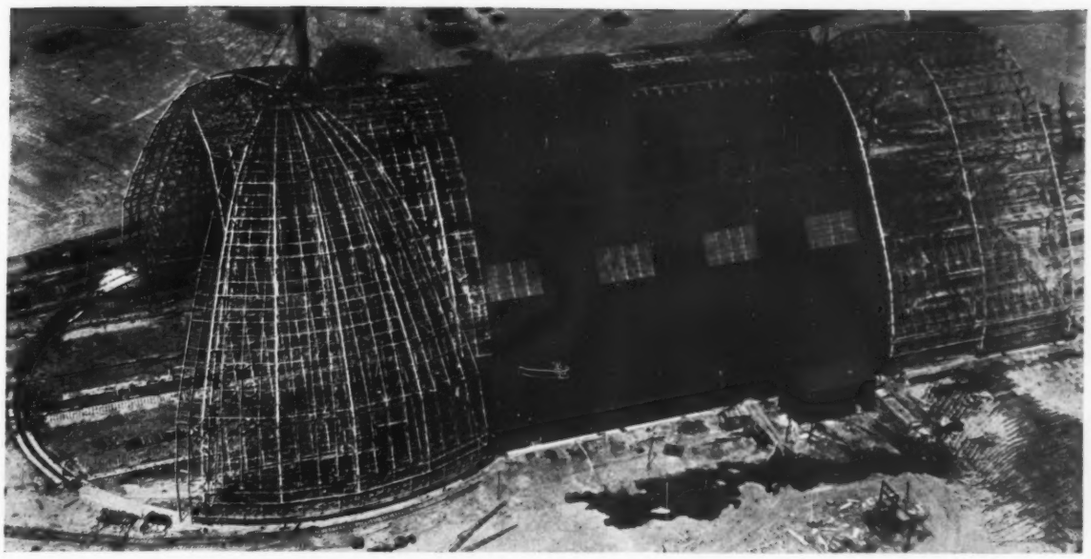


*Fig. 4—General view of hangar, under construction, showing open doors at left*

fixed in the same spot, although tons of metal are used to make it fast, because in a building so large as this the sun's heat will cause expansion and contraction that will move the entire roof and wabble the pin around several inches. To provide for this movement of the hinge pins, the thrust bearing is made a ball and socket joint, free to move in any direction within moderate limits. The pin, shown in Figs. 5 and 6, is 17 inches in diameter, about 6 feet long and the bearing ball is about 30 inches in diameter. The bearing can move up and down on the pin 4 inches each way to provide for change in height of door due to expansion and contraction.

Since it is imperative that the doors be under control at all times and not subject to starting off by themselves to swing around and cause wreckage in a heavy wind, it was decided to use a "rack drive" system for operating them.

### Worm Gear Also Prevents Swinging

These devices consist of a heavy bull gear mounted horizontally on a fixed concrete base just outside of the dock (one at each corner of the building) set far enough to the side to be in the clear of the open yard in front. As indicated in Figs. 1 and 3, this gear is revolved by a train of gears connected to a 125-horsepower motor through a worm gear reduction. The worm gear reduction is selected because of its characteristic of being "self locking" so that as soon as the power of the motor is shut off, the gear stops and cannot be started by pressure of wind.

The bull gear engages a rack built to surround the base of the door at the bottom, just above the wheels near the ground. This rack, which consists of a 14-inch H-beam with 4-inch diameter pins set on 9-inch pitch, is rigidly attached to the door in a vertical position. As the motor revolves the bull gear slowly the rack is driven back and forth and pushes the door along with it. Adjustment is provided for setting the bull gear in the pitch line of the rack by jack screws and a spring, allowing limited variation for moderate unevenness in construction of the rack.

The motor is special in that it is capable of being used at two speeds with a constant torque

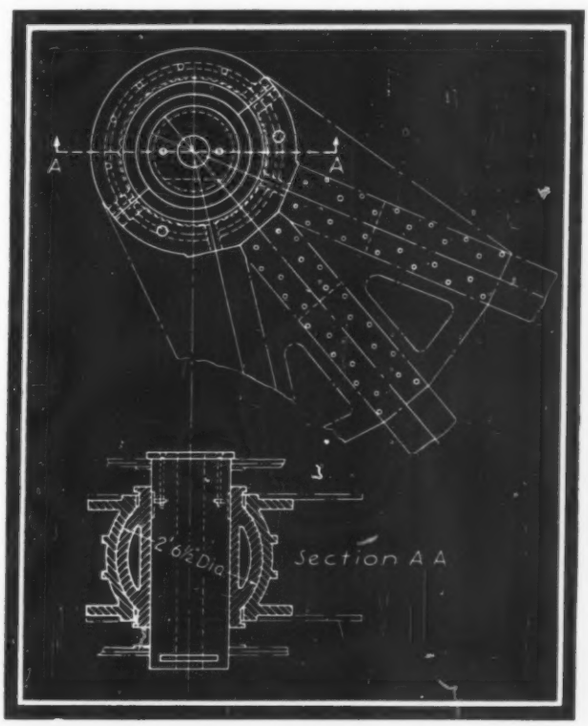



*Fig. 5—Huge hinge pin for fastening top of door. Note clearance for expansion*

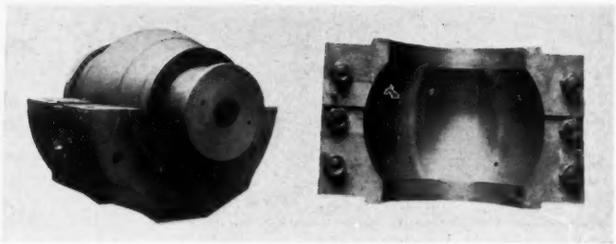


*Fig. 6—Views of door hinge pin and cap*

effort. It is connected by a flexible coupling and is of 125/62 horsepower with synchronous speed of 600/300 revolutions per minute, and is arranged for a 440-volt, 3-phase, 60-cycle current with a capacity of 200/100 horsepower at a 15-minute rating.

Electric cutout switches are mounted on the runway adjacent to the driving units so that as projections from the door operate them, the door comes to a slow down and creeping speed, automatically as the two leaves come together at the center, or as the doors come to the extreme open position. This makes it only necessary for the operator to push a button to start the door after which it will open and stop, or close and stop, as the case may be, automatically.

The driving units are set under separate roofs outside the hangar for the reason that the pressure of the gear against the rack resists the outward pressure against the wheels due to the door weight, and because there can be no objectionable sparks from the control switches in case hydrogen gas is ever used in dirigibles.

Operation of the door is as follows: Pressing the open or close button starts the equipment on the high-speed motor winding and accelerates the motor to full speed. Travel continues at full speed until the first slow-down limit switch is encountered in that direction. This inserts secondary resistance in the high-speed winding, causing the motor to slow down. When the second slow-down switch is encountered, the motor becomes disconnected from the high-speed winding and is thrown into slow speed connections with secondary resistance. This causes the motor to decelerate to half speed or below, depending upon the amount of secondary resistance left in the circuit on the low speed winding. With 80 to 100 per cent normal torque on the motor, the final slow speed is approximately one-third of the top speed. The door then continues at such slow speed until the final stop at which time the power is entirely disconnected from the equipment, including the hydraulically operated brake. The hydraulic brake is arranged so that after cutting off the power, there is an inherent time lag to 1½ to 2½ seconds before the brake is finally set. It should be noted that the setting of the brake is a gradual application. Operation in the reverse direction is the same as that outlined. Doors can be opened or closed in 5 minutes.

The engineering personnel engaged in the design and construction of the factory and dock includes P. W. Litchfield, president; Dr. Karl Arnstein, director of engineering; and W. C. State, consulting engineer of the Goodyear Zeppelin Corp.; Wilbur Watson & Associates, architects and engineers; and F. E. Hulett, Hulett Engineering Co., Cleveland, who was associated with the Watson organization as consultant on the operating equipment for the doors. The Wellman-Seaver-Morgan Co., Cleveland, built the operating equipment for the doors, and the General Electric Co., Schenectady, N. Y., provided the motors and other electrical equipment.

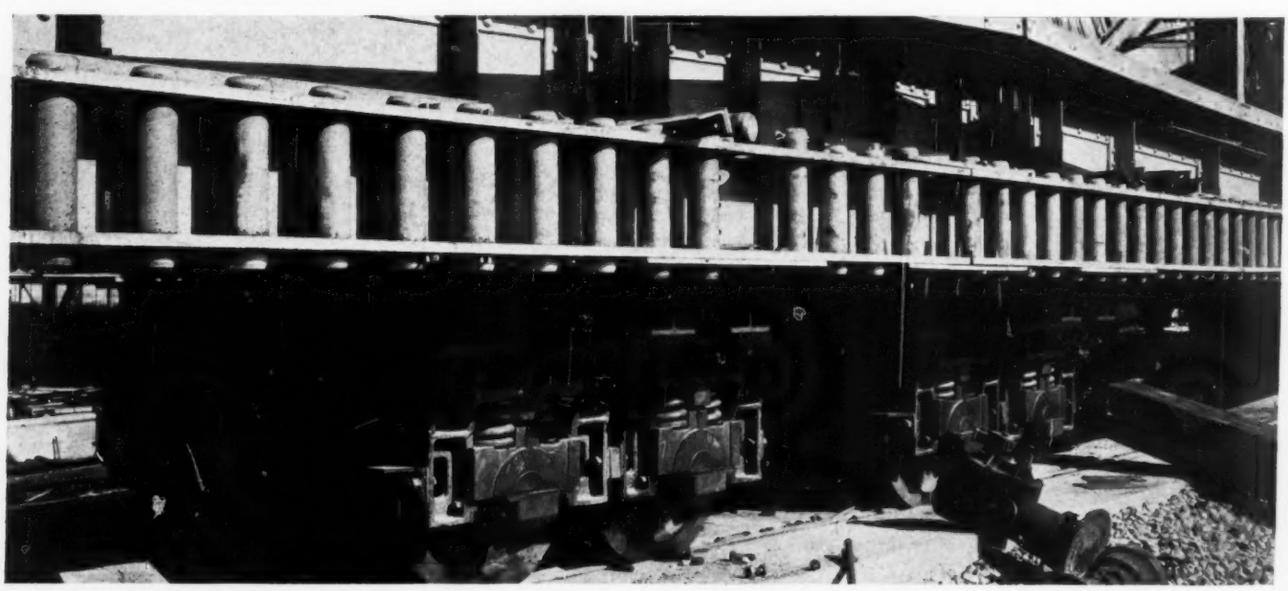


*Fig. 7—Door trucks and rack. The rack pins are 4 inches in diameter, set at 9-inch pitch*

# Timely Re-statement of Fundamental Mechanical Principles

By Prof. John V. Martenis, M. E.
*Chief, Machine Design Division,*
*University of Minnesota*

## *Stresses in Riveted and Screwed Fastenings*

THE rivet furnishes a convenient means of forming a rigid and permanent fastening. Present methods of welding are displacing the rivet in many cases and eventually may become the accepted method for use on internal pressure vessels including steam boilers. However, at present the rivet still is employed to a considerable extent.

Riveted fastenings can be considered under two principal heads, (a) General construction i. e., structural work, bridges, etc., in which tensile, compressive and shearing stresses determine the number and size of rivets necessary; (b) Pressure vessels and fluid containers, i. e., boilers, tanks, stand pipes, etc., in which the element of leakage forms an additional problem to be considered.

### Load on Rivets Must Be Considered

In structural work the arrangement of rivets can be adapted to the space available but a sufficient number must be used to carry the load imposed upon them. The minimum distance between rivet centers can be taken as 3½ rivet diameters.

The shearing stress will, in most cases, be the principal one to consider in the determination of size and number of rivets to use in a given case. Since the value of shearing stress is less, in iron and steel, than the other forms of stress, a rivet designed for shear will be amply strong for tension and compression.

A factor of safety of four can be used for steady stresses, a condition which will apply to many cases of riveted joints; but in the case of a steam boiler where there is an imminent risk to human life or of serious property damage, a factor of five, is required.

In the analysis of stress action set up in the walls of a cylinder subject to internal pressure, it will be assumed in the present case that the walls are thin and that the stress is evenly distributed—a condition that cannot be assumed where the walls are thick and thus involve considerable difference in stresses between the inner and outer surfaces since the stress varies directly as the distance of the fiber from the neutral axis which in this case is the cylinder axis.

In Fig. 1, let $P$=gage pressure, in pounds per square inch; $D$=diameter of cylinder, in inches; $t$=thickness of plate, in inches; $S_t$=ultimate tensile strength of materials, in pounds per square inch; $xy$=element of cylindrical shell.

The internal pressure $P$ is exerted equally in all directions and in the transverse section shown acts along radial lines.

The load on $xy$ is $P\ xy$ per unit length and this load can be resolved into components acting in any required direction. In the sketch the component of $xy$ in the horizontal plane is $xz$ and the load or force exerted by this component is $P\ xz$, which force tends to pull the sheet apart in the horizontal plane. It is apparent that the

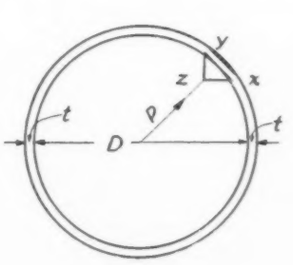


Fig. 1

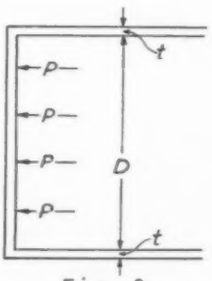


Fig. 2

summation of the horizontal components of $xy$, between the limits $O$ and $\pi$ is equal to the diameter $D$ of the cylinder and that the total force acting on the horizontal plane is $P\ D$ which force tends to pull the sheet apart at the terminals of the diameter $D$. The resistance to this load consists of two shell thicknesses $t$ having a tensile stress $S_t$ or $2\ t\ S_t$. Equating force and resistance,

$$PD = 2tS_t \text{ or } t = \frac{PD}{2\,S_t}$$

which fundamental relation must be modified for practical application.

Using the same notation and referring to Fig. 2, consider the force acting upon the head of a cylindrical drum, where the total force is

$$P\ \frac{\pi D^2}{4}$$

The resistance offered by the annular ring of sheet is

$$\pi\ (D+t)t\ S_t$$

and equating force and resistance,

$$P\ \frac{\pi D^2}{4} = \pi\ (D+t)t\ S_t \text{ or } P\ \frac{D^2}{4} = Dt\ S_t + t^2\ S_t$$

Assuming that $t$ is negligible compared to $D$ permits the omission of the last term, in which case

$$t = \frac{PD}{4S_t}$$

Comparing the expressions derived for $t$ in Figs. 1 and 2 it is apparent that a cylindrical shell is twice as strong longitudinally as it is transversely when subjected to internal pressure and therefore must be designed for the greater stress. This also explains why the longitudinal seams in boiler construction are made stronger than the circumferential or ring seams.

### Thick Walled Cylinders

Cylinders formed of cast metal, like engine

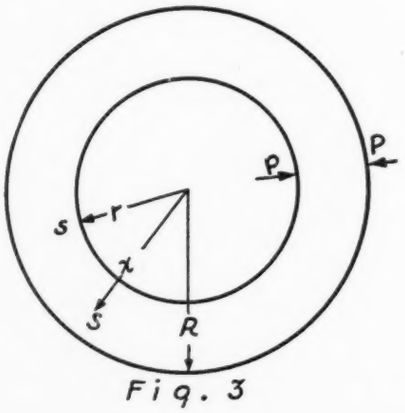


Fig. 3

cylinders, heavy drums, etc., have a wall thickness in which the stresses cannot be assumed to be uniformly distributed as in the previous discussion. Whether the pressure is internal or external the stress in the wall is greatest at the inner surface and decreases to a minimum at the outer surface.

Claverino's modification of Lame's formula appears to be the simplest form of expression applicable to thick walled cylinders.

The general form of this expression,

$$S = \frac{r^2P - R^2P + \frac{4r^2\ R^2}{X^2}\ (p-P)}{3(R^2-r^2)}$$

in which, as at Fig. 3, $S$=unit stress at any radius $x$; $r$= inner radius of cylinder; $R$=outer radius of cylinder; $p$=internal pressure, in pounds per square inch; $P$=external pressure, in pounds per square inch.

If gage pressures are used, then $P=O$ when the external surface is subject to atmospheric pressure and letting $x=r$, then the maximum stress $s$ which is at the inner surface is,

$$s = \frac{p(r^2+4R^2)}{3(R^2-r^2)} \text{ or } R = r\left(\frac{3s+p}{3s-4p}\right)^{1/2}$$

### Design of Riveted Joints

There are two general classes of riveted joints: *Lap* joints where the ends of the rolled sheet overlap each other and *Butt* joints where the ends of the rolled sheet butt against each other. In the sketch, Fig. 4 shows a lap joint, and Fig. 5 shows a butt joint in which it is necessary to use cover plates (butt straps) as shown. It is evident from an inspection of the figures that a lap joint forms a distorted cylinder while the butt joint conforms to a true cylinder. Hence the latter is the better form to use for boiler construction and for high pressures although it is more expensive to make than the lap joint.

Riveted joints are further classified by the number of rows of rivets used in the joint, thus: single, double, triple, etc. riveted for one, two, three, or more rows of rivets except in the case of butt joints where the number of rows is usually counted from the seam. In general, the pitch increases with the number of rows of rivets. The term *pitch*, as here used means the distance between centers of adjacent rivets in the same row. In double riveted joints the rivets may be arranged in alternation called *staggered* riveting or in line called *chain* riveting (see sketches). The staggered arrangement is most used, permitting a greater pitch than the chain arrangement.

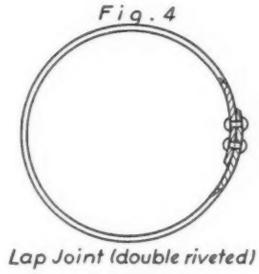
### Analysis of Single Riveted Lap Joint

There are five possible ways in which a single riveted joint may fail, (a) shear rivet; (b) shear plate (ahead of rivet); (c) tear plate (in

front of rivet); (d) crush plate or rivet; (e) tear plate between rivet holes. In design practice, all of these forms of failure except (e), can be safeguarded by a judicious selection of rivet size and by placing the rivet a suitable distance back from edge of plate. The form of failure (e) is the one most commonly occurring and its resistance can be improved by increasing the pitch but on account of security against leakage the pitch, for a seam of an internal pressure vessel, is limited by the degree of required tightness produced in the construction of the seam. This tightness can be greatly improved in most cases by calking.

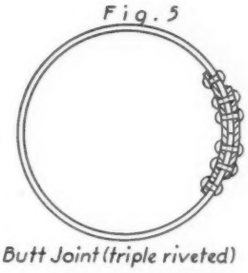
If the customary practice of placing the rivet-center one and one-half rivet diameters back from

Fig. 4

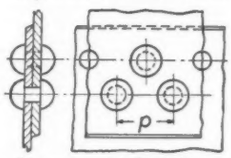


Lap Joint (double riveted)

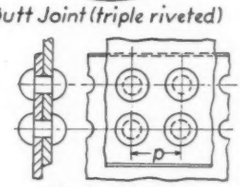
Fig. 5



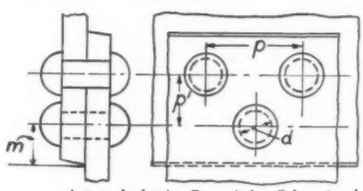
Butt Joint (triple riveted)




Staggered Riveting




Chain Riveting




p'-back pitch
m-margin=1½d

Lap Joint-Double Riveted

the edge of the plate, shearing and tearing the plate in front of the rivet will be prevented, therefore three forms of failure remain to be considered, namely, (a) shear rivet; (d) crush plate or rivet; (e) tear plate between rivet holes.

To design a joint that will be equally strong for the three cases equate (a), (d), (e), thus,

$$\text{(a)}\ \frac{\pi}{4}\,d^2S_s = \text{(d)}\ dtS_c = \text{(e)}\ (p-d)tS_t$$

Steel of a quality specified for boiler construction will have a shear stress $S_s$ equal to 0.8 tensile stress $S_t$ and a compressive stress $S_c$ equal to 1.7 tensile stress (approximately), hence the above expressions can be simplified, thus,

$$\text{(a)}\ \tfrac{5}{8}d^2S_t = \text{(d)}\ 1.7dtS_t = \text{(e)}\ (p-d)tS_t$$

*Equating* (a) *and* (d), $\frac{5}{8}d^2 = 1.7dt \therefore d = 2.7t$

*Equating* (d) *and* (e), $1.7dt = (p-d)t \therefore p = 2.7d$

In which, $d$=diameter of rivet hole; $t$=thickness of plate; $p$=pitch of rivets.

The above expressions are not suitable for heavy pressure vessels because the pitch is too great to prevent leakage and the rivet sizes are larger than common usage specifies.

The *efficiency* of a riveted joint is defined as the ratio of the weakest element of the joint to the strength of the solid plate, each taken over the pitch distance. By observing the previously mentioned precautions against joint failure, it may be assumed that a joint will fail by tearing the plate between the rivet holes, in which case the efficiency will be represented by the expression,

$$E_f = \frac{p-d}{p}$$

The following table of efficiencies will serve as a guide in the design of a riveted joint, keeping in mind that the efficiency quoted is a maximum for the particular type of joint.

TABLE I

**Efficiency of Riveted Joints (Maximum)**

| Lap Joint | | Butt Joint (two cover plates) | |
|---|---|---|---|
| Single-riveted | $E_f$ 60% | Single-riveted | $E_f$ 65% |
| Double-riveted | $E_f$ 75% | Double-riveted | $E_f$ 82% |
| Triple-riveted | $E_f$ 84% | Triple-riveted | $E_f$ 90% |
| | | Quadruple-riveted | $E_f$ 95% |

The size of driven rivet bears a certain relation to the thickness of the plate with which it is to be used and that relation is approximately expressed by, $d$=0.8 t + 0.5 inch. To illustrate the application of the foregoing relations, assume a lap joint, single-riveted, and a plate thickness, $t$=¼ inch. Then, $d$=0.7 inch; use 11/16 inch rivets. The maximum efficiency of the joint is 60 per cent, therefore, the pitch is 1.719 inches which may be rounded off to 1⅝ inches since 1¾ inches would give an efficiency greater than 60 per cent. Using $p$=1⅝ inches, the corrected efficiency is 57.7 per cent.

Compare these values with those of a joint having uniform strength, in which, $d$=2.7 $t$=0.675; use 11/16-inch rivets, and $p$=2.7 $d$=1.856, which may be rounded off to 1¾ inches pitch, giving an efficiency of 60.7 per cent.

### Lap Joint, Double Riveted

In the double riveted lap joint (see sketch) there are three forms of failure to be considered, (a) tearing plate between rivet holes; (b) shear of two rivets (single shear); (c) crushing plate in front of two rivets.

There is another form of possible failure in this joint, namely that of tearing plate between front and back rows of rivets but this is safeguarded by suitably spacing the rows of rivets

(back pitch). For safety use back pitch=$2d$ (minimum).

Using the same notation as before, the three forms of failure can be expressed as follows:

(a) tearing plate between rivet holes,

$$(p—d)\,tS_t$$

(b) shear two rivets (single shear)

$$\frac{2\pi d^2}{4}\,S_s$$

(c) crush two rivets (or plate)

$$2dtS_c$$

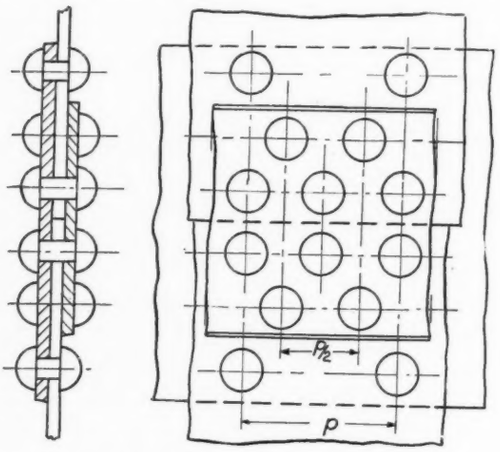
In this form of joint, failure (a) will usually occur, therefore

$$E_f = \frac{p—d}{p}$$

The A.S.M.E. boiler code recommends for steam boiler practice that $S_t$=55,000 pounds, ultimate tensile strength; $S_s$=44,000 pounds. ultimate shearing strength; $S_c$=95,000 pounds, ultimate compressive strength.

### Butt Joint

The butt joint is the better type for high pressures and is mandatory for steam boilers carrying pressures above 15 pounds gage. In this type of joint either one or two butt straps (cover plates) may be used and common practice uses two butt straps on all longitudinal seams. The stress analyses to determine efficiency of the joint follow lines similar to those used for the lap joint except the shearing of rivets where two butt straps are used, in which case some rivets will be subject to double shear.



Butt Joint - Triple Riveted

### Butt Joint. Triple Riveted (Two Cover Plates)

Taking this form of butt joint as a typical example, it will be found that there are six forms of failure to consider, namely,

(a) tearing plate between rivet holes in outer row=$(p—d)\ tS_t$.

(b) four rivets in double shear + one rivet in single shear=

$$4 \times \frac{2\pi d^2}{4}\,S_s + \frac{\pi d^2}{4}\,S_s = \frac{9\pi d^2}{4}\,S_s$$

(c) tearing plate between rivet holes in second row + shear of rivet in outer row=

$$(p—2d)\,t\ S_t + \frac{\pi d^2}{4}\,S_s$$

(d) tearing plate between rivet holes in second row + crushing of butt strap or rivet in outer row ($b$=thickness of butt strap)=

$$(p—2d)\,t\ S_t + d\,b\,S_c$$

(e) crushing plate in front of four rivets + crushing of butt strap or rivet in outer row=

$$4d\ t\ S_c + d\ b\ S_c$$

(f) crushing of plate in front of four rivets + shear of rivet in outer row=

$$4d\ t\ S_c + \frac{\pi d^2}{4}\,S_s$$

In all cases the pitch used is that in the outer row of rivets. The pitch for the inner rows of rivets is one-half that of the outer row.

In the analyses of the strength of the various elements in all types of riveted joints, it will be found that the most common form of weakness or failure lies in the tearing of the sheet between rivet holes and with this assumption, the efficiency of the joint is,

$$E_f = \frac{p—d}{d}$$

Using this expression for efficiency, and assuming the maximum values previously given, the relation of pitch and rivet diameter for various types of joints is,

Lap Joint:

*Single-riveted;* $E_f$, 60% or $\frac{p—d}{p} = 0.6 \therefore p = 2.5d$

*Double-riveted;* $E_f$, 75% or $\frac{p—d}{p} = 0.75 \therefore p = 4d$

Butt Joint:

*Double-riveted;* $E_f$, 82% *or* $\frac{p—d}{p} = 0.82 \therefore p = 5.5d$

*Triple-riveted;* $E_f$, 90% or $\frac{p—d}{p} = 0.9 \therefore p = 10d$

*Quadruple-riveted;* $E_f$, 95% or $\frac{p—d}{p} = 0.95 \therefore p = 20d$

### Example of Triple Riveted Joint

A steam boiler, 60 inches in diameter will be designed to carry a pressure of 125 pounds gage;

the fundamental relation,

$$t = \frac{P\ D}{2S_t}$$

must be modified to include a safety factor $F$ and the efficiency of the riveted joint $E_t$, thus

$$t = \frac{P\ D\ F}{2S_t\ E_f}$$

which is a general formula for cylindrical shells.

Substituting known values in the above formula, that is, $P$=125; $D$=60; $F$=5; $S_t$=55,000 (for boilers); $E_t$=90 per cent (triple-riveted butt seam), then $t$=0.378 inch; use 3/8 inch plate. And $d$=0.8 $t$ + 0.5=0.8 inch, use 13/16 inch rivets. Thickness of butt straps, 5/16 inch. Using the maximum value of $E_t$=90 per cent then $p$=8.125, say 8 inches. Comparing the strength of solid plate having length $p$ with the various elements in this joint, then strength of solid plate, 165000; (a) 148240; (b) 205326; (c) 154298; (d) 155605; (e) 139902; (f) 138505. $\therefore E_t$=138505÷165000=0.839 or 83.9 per cent is the efficiency of the joint and indicates that the rivets are too small or the pitch is too large. The size of rivets used conforms to the plate thickness therefore the pitch will be investigated. The inner rows of rivets are arranged in the customary manner for a double riveted joint for which the maximum $E_t$=75 per cent, and the corresponding pitch is 3¼ inches. The outside pitch $p$ is double the inside pitch for a triple riveted joint or 6½ inches. Using the corrected pitch, then, strength of solid plate 134062; (a) 117304; (b) 205326; (c) 123360; (d) 124667; (e) 139902; (f) 138505 and 117304÷134062=0.875 or 87.5 per cent is the efficiency of the joint which indicates better proportions in the design of the joint. If the first found pitch, 8 inches, had been used, it is doubtful if the joint would be steam tight.

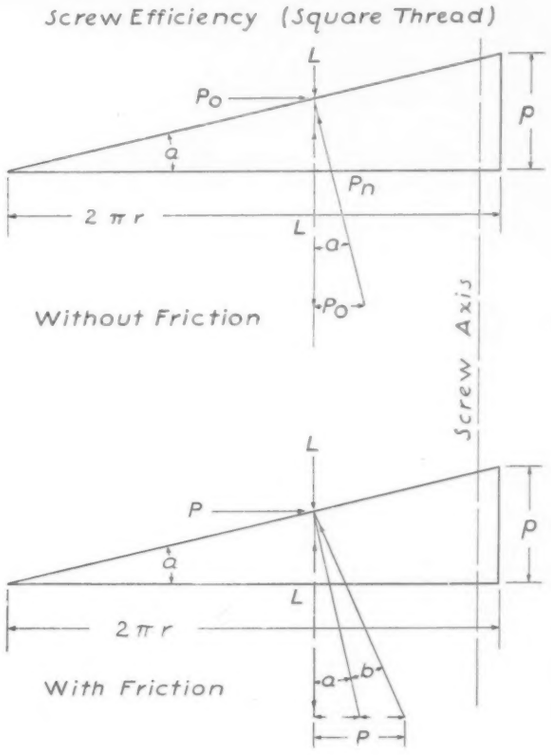
### Screw Fastenings

Pieces that may require removal, replacement or adjustment are usually fastened together by some form of screwed connection.

Threaded pieces or screws are also used for the transmission of power, change of position of a member and to provide a large mechanical advantage.

The form of thread to be used in each case will be determined by the result sought. For fastenings, the screw should have a low efficiency, say less than 50 per cent, while a screw used for power transmission should have a relatively high efficiency. *Efficiency* may be defined as the ratio of useful work done to the work expended. Since work is defined as the product of force and distance through which the force acts, the conception of work is not apparent in cases where there is no appreciable motion, therefore a common form of transmission screw with a square thread will here be discussed for an illustrative purpose.

Sketch shows development of a square thread, in which, $2\pi r$ is the mean perimeter of the screw, and $p$ is the pitch (or lead) and $a$ is the lead angle. The load $L$ acting parallel to the axis of the screw is supported by a reaction $P_n$ normal to the thread surface and a force $P_o$ normal to




the screw axis. A diagram of these forces shows, $P_o$=$L$ tan $a$.

When friction is considered, the force $P_o$ increases to $P$ and the coefficient of friction $f$=tan $b$, where $b$ is the friction angle.

A diagram of these latter forces shows that, $P$=$L$ tan $(a+b)$.

$$Efficiency = \frac{without\ friction}{with\ friction} = \frac{P_o}{P} = \frac{tan\ a}{tan\ (a+b)}$$

From the sketch

$$tan\ a = \frac{p}{2\pi r}$$

Since

$$tan\ (a+b) = \frac{tan\ a + tan\ b}{1 - tan\ a\ tan\ b}$$

the expression for efficiency can be shown in a form containing no trigonometric functions, thus,

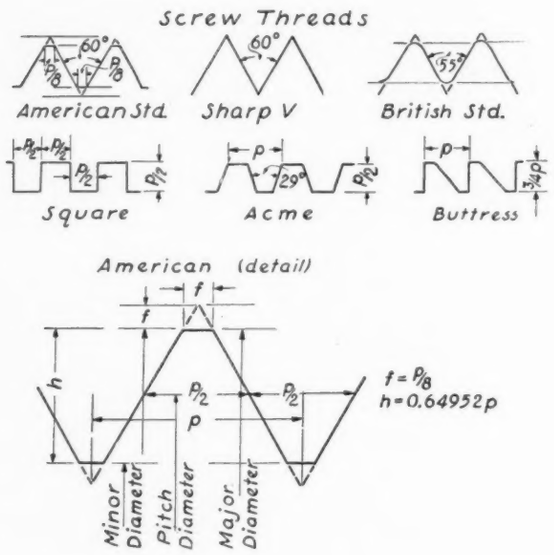
$$Efficiency = \frac{p(2\pi r - pf)}{2\pi r(p + 2\pi rf)}$$

### Screw Threads

The principal forms of screw threads are

shown in the sketch and it will be noted that the thread surface either forms an oblique angle with the screw axis or is perpendicular to it. In the diagram, the normal pressure between the threads of bolt and nut is resolved into components, one of which is parallel and the other perpendicular to the screw axis. The first component is the effective part of the force exerted and the second component produces a bursting action on the nut. It is evident that the bursting action on the nut becomes less as the line of normal pressure approaches a position parallel to the screw axis, that is, when the thread surface is perpendicular to the screw axis, therefore the square and buttress forms of threads give the highest efficiency in power transmission.

The relative merits of screw threads can be




summed up, thus:

(1) Sharp-V. Top of thread weak and easily bruised; bottom of thread forms a starting point for bolt fracture and weakens the bolt.

(2) American standard (Sellers). Generally used in machine practice and is more substantial and stronger than the sharp-V type.

(3) English standard (Whitworth). The rounded form of thread used is not easily damaged and the effective area of bolt is greater than the American standard, also the rounded bottom of thread reduces liability to fracture.

(4) Square. Possesses high efficiency; expensive to make; difficult to compensate for wear; weaker in shear than the V-types. Used principally for power transmission.

(5) Acme. Cheaper to make than the square and wear can be compensated. Used for power transmission and principally on lathe lead screws.

(6) Buttress. Rugged type combining strength of V-types and high efficiency of square. Used for power transmission and for motion in one direction only. Well adapted to locking purposes, for instance, the breech blocks of large guns.

*Pitch* is defined as the distance between corresponding points on adjacent screw threads measured parallel to the screw axis and is a measure of the coarseness of the thread. Pitch is the reciprocal of the number of threads per inch.

*Lead* is defined as the distance a screw thread advances axially in one turn. Pitch and lead are the same on a single-thread screw.

There are two ways in which a bolt subject to a pull may fail; it may either break in the root area or shear the engaged threads. But the latter form of failure is preventable in a well made bolt by allowing for the engagement of a sufficient number of threads, therefore it is apparent that the strength of a bolt in tension depends upon the area at root of thread, other factors being equal.

In our standard American practice there are two thread series adopted, namely, "coarse-thread" and "fine-thread." The following tables of these two series up to 1-inch diameter, as approved by the American Engineering Standards committee, will give some essential details and enable comparisons to be made.

*Major diameter* is the largest diameter of a screw thread and replaces the term "outside diameter" as applied to the thread of a screw and the term "full diameter" as applied to the thread of a nut.

*Minor diameter* is the smallest diameter of a screw thread and replaces the term "root diameter" as applied to the thread of a screw and the term "inside diameter" as applied to the thread of a nut.

*Pitch diameter* of a regular screw thread is that of an imaginary cylinder which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cylinder (see sketch).

The relative tensile strengths vary as the square of the minor diameters; for example, a 1-inch bolt in the fine-thread series is 17.6 per cent stronger in tension than a 1-inch bolt in the coarse-thread series.

### Bolt Stresses

A bolt supporting a load will be subject to

TABLE II
Coarse-Thread Series

| Size | Threads (per inch) | Diameters Major | Pitch | Minor | Depth of thread |
|---|---|---|---|---|---|
| 1 | 64 | 0.0730 | 0.0629 | 0.0527 | 0.01014 |
| 2 | 56 | 0.0860 | 0.0744 | 0.0628 | 0.01160 |
| 3 | 48 | 0.0990 | 0.0855 | 0.0719 | 0.01353 |
| 4 | 40 | 0.1120 | 0.0958 | 0.0795 | 0.01624 |
| 5 | 40 | 0.1250 | 0.1088 | 0.0925 | 0.01624 |
| 6 | 32 | 0.1380 | 0.1177 | 0.0974 | 0.02030 |
| 8 | 32 | 0.1640 | 0.1437 | 0.1234 | 0.02030 |
| 10 | 24 | 0.1900 | 0.1629 | 0.1359 | 0.02706 |
| 12 | 24 | 0.2160 | 0.1889 | 0.1619 | 0.02706 |
| ¼ | 20 | 0.2500 | 0.2175 | 0.1850 | 0.03248 |
| 5/16 | 18 | 0.3125 | 0.2764 | 0.2403 | 0.03608 |
| ⅜ | 16 | 0.3750 | 0.3344 | 0.2938 | 0.04060 |
| 7/16 | 14 | 0.4375 | 0.3911 | 0.3447 | 0.04640 |
| ½ | 13 | 0.5000 | 0.4500 | 0.4001 | 0.04996 |
| 9/16 | 12 | 0.5625 | 0.5084 | 0.4542 | 0.05413 |
| ⅝ | 11 | 0.6250 | 0.5660 | 0.5069 | 0.05905 |
| ¾ | 10 | 0.7500 | 0.6850 | 0.6201 | 0.06495 |
| ⅞ | 9 | 0.8750 | 0.8028 | 0.7307 | 0.07317 |
| 1 | 8 | 1.0000 | 0.9188 | 0.8376 | 0.08119 |

either of two stresses, tension or shear, or possibly a combination of the two.

Cases involving simple shear are comparatively few, due to the necessity for tightening the bolt into position, thus inducing tension.

The determination of the size of a bolt to withstand simply tension or shear is an easy matter but the stresses introduced by the tightening of the bolt are not within the control of the designer, therefore it is customary to recognize this fact by using a suitable safety factor.

A bolt subject to shear should have a reamed fit and avoid the shear action coming on the threaded portion.

The following permissible stresses in pounds per square inch may be used: small bolts, 3000; medium bolts, 6000; large bolts, 9000 for average bolt material and variable load conditions. These values may be materially increased for purely dead loads and for high grade materials.

In the selection of the size of bolt to use in any given case it should be kept in mind that the bolt will be subject to an initial tensile stress due to the tightening action and a twist due to thread friction which will vary with the accuracy and smoothness of the thread surface.

A bolt will in all cases be stressed to the amount of external load it must carry and if tightness against fluid leakage is involved an additional stress in the bolt is necessary, especially so if the contact surfaces are somewhat elastic in nature as is found in the case of a gasket joint.

Many results obtained from the data in the following discussion on bolt stresses have been checked by actual tests:

TABLE III
Fine-Thread Series

| Size | Threads (per inch) | Diameters Major | Pitch | Minor | Depth of thread |
|---|---|---|---|---|---|
| 1 | 72 | 0.0730 | 0.0640 | 0.0550 | 0.00902 |
| 2 | 64 | 0.0860 | 0.0759 | 0.0657 | 0.01014 |
| 3 | 56 | 0.0990 | 0.0874 | 0.0758 | 0.01160 |
| 4 | 48 | 0.1120 | 0.0985 | 0.0849 | 0.01353 |
| 5 | 44 | 0.1250 | 0.1102 | 0.0955 | 0.01476 |
| 6 | 40 | 0.1380 | 0.1218 | 0.1055 | 0.01624 |
| 8 | 36 | 0.1640 | 0.1460 | 0.1279 | 0.01804 |
| 10 | 32 | 0.1900 | 0.1697 | 0.1494 | 0.02030 |
| 12 | 28 | 0.2160 | 0.1928 | 0.1696 | 0.02319 |
| ¼ | 28 | 0.2500 | 0.2268 | 0.2036 | 0.02319 |
| 5/16 | 24 | 0.3125 | 0.2854 | 0.2584 | 0.02706 |
| ⅜ | 24 | 0.3750 | 0.3479 | 0.3209 | 0.02706 |
| 7/16 | 20 | 0.4375 | 0.4050 | 0.3725 | 0.03248 |
| ½ | 20 | 0.5000 | 0.4675 | 0.4350 | 0.03248 |
| 9/16 | 18 | 0.5625 | 0.5264 | 0.4903 | 0.03608 |
| ⅝ | 18 | 0.6250 | 0.5889 | 0.5528 | 0.03608 |
| ¾ | 16 | 0.7500 | 0.7094 | 0.6688 | 0.04060 |
| ⅞ | 14 | 0.8750 | 0.8286 | 0.7822 | 0.04640 |
| 1 | 14 | 1.0000 | 0.9536 | 0.9072 | 0.04640 |

## General

In the design of a bolt the stresses set up due to tightening the nut must be considered as well as the stresses due to the external load. While the nut is being tightened two types of stresses are set up in the bolt; a direct tensile stress, and a shear stress due to the torque. These stresses may be combined to obtain the maximum tensile stress. After the tightening process has been completed the direct tensile stress is all that remains. Both of these stresses should be calculated.

TABLE IV
Loads, Stresses (10-Pound Wrench Pull)

| Size | Coarse-thread Series: Length of Wrench | Load | Direct Tensile Stress | Max. Stress | Fine-thread Series: Load | Direct Tensile Stress | Max. Stress |
|---|---|---|---|---|---|---|---|
| ¼ | 5¼ | 805 | 33629 | 42730 | 975 | 29980 | 36190 |
| 5/16 | 6 | 895 | 19730 | 24580 | 966 | 18420 | 22130 |
| ⅜ | 7 | 884 | 13050 | 16100 | 969 | 12000 | 14180 |
| 7/16 | 8 | 875 | 9390 | 11520 | 962 | 8820 | 10420 |
| ½ | 9 | 871 | 6930 | 8950 | 940 | 6340 | 7430 |
| 9/16 | 10 | 868 | 5350 | 6490 | 921 | 4870 | 5710 |
| ⅝ | 11 | 864 | 4280 | 5190 | 928 | 3865 | 4500 |
| ¾ | 13 | 863 | 2856 | 3424 | 931 | 2650 | 3080 |
| ⅞ | 15 | 860 | 2050 | 2450 | 919 | 1911 | 2215 |
| 1 | 17 | 856 | 1551 | 1852 | 916 | 1415 | 1631 |

The load and the maximum tensile stress set up in a bolt when tightening the nut are controlled by the factors: length of wrench; pull on wrench; coefficient of thread friction; coefficient of friction between the nut and the surface on which it seats.

The accompanying table gives the load and stresses set up in a bolt due to a ten pound pull at the end of a standard length wrench and coefficients of nut and thread friction of 15 per cent.

## Use of Table and Charts

When coefficients of nut and thread friction other than .15 are used the stresses in the table

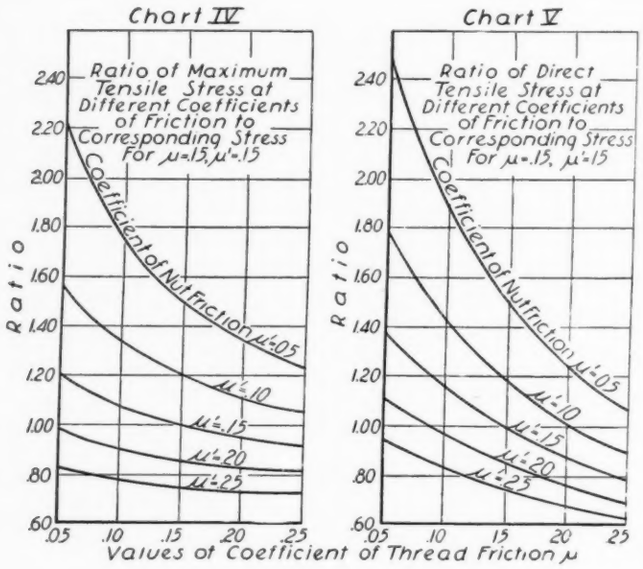
must be multiplied by the ratio shown in Chart IV for maximum tensile stress, and Chart V for the direct tensile stress.

Since the stresses set up in a bolt are directly proportional to the wrench pull and length of wrench, stresses for conditions other than those given in the table may easily be calculated.

As an example of the use of the table and charts let it be required to determine the stresses in a ¾-inch United States standard bolt due to a wrench pull of 40 pounds, assuming a 14 per cent coefficient of nut friction and 12 per cent coefficient of thread friction.

From the table the stresses due to a 10-pound wrench pull and 15 per cent coefficients of friction are:

$S_t = 2856$ *pounds per square inch*
$S_t^1 = 3424$ *pounds per square inch*




The corresponding values for a 40-pound wrench pull are:

$S_{t_p} = 40 = 2856 \times 40/10 = 11424$ *pounds per square inch*
$S_{t^1_p} = 40 = 3424 \times 40/10 = 13696$ *pounds per square inch*

The value of the ratios corresponding to the coefficients assumed for the problem may be taken from charts IV and V as 1.085 for the maximum tensile stress and 1.140 for the direct tensile stress. The stresses in the bolt are, therefore;

$(S_t)_p = 40 = 1.140 \times 11424 = 13030$ *pounds per sq. in.*
$(S_t^1)_p = 40 = 1.085 \times 13696 = 14850$ *pounds per sq. in.*

In the usual form a bolt will break through the section at root of threads, principally due to the lesser area at that point but secondarily on account of a lack of opportunity for the material to stretch an appreciable amount under the stress action. These conditions may be greatly improved by reducing the bolt area either by turning down the body of the bolt or by drilling out an appropriate amount of material. This latter method has certain advantages over the former because the material at the core is of minor importance to resist stress action.

### Nuts and Bolt Heads

Since nuts and bolt heads, like rivet heads, are largely standardized they do not come within the sphere of design practice unless conditions arise which require deviations from established usages. The minimum thickness of a nut can be found by equating the shear resistance of threads in the nut to the tensile strength of the bolt at the net section and the result will show that it is not safe to use a nut thickness less than five-eighths the bolt diameter. The minimum thickness of bolt head can be found by equating the shear resistance of head to the tensile strength of bolt at the net section which will show that the minimum thickness of bolt head should be half the bolt diameter.

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## Committees Report on Progress in Standardization of Gears

Evidence that rapid strides are being made in the standardization of gears was revealed in the reports of various committees at the semiannual meeting of the American Gear Manufacturers' association, held at Philadelphia, Oct. 24-26.

The association has a general standardization committee, headed by B. F. Waterman, engineer, Brown & Sharpe Mfg. Co., Providence, R. I., with 12 sub-committees. A. A. Ross, engineer, metal gear department, General Electric Co., Lynn, Mass., chairman of the committee on herringbone gears, submitted a recommended design practice for herringbone gears, which was accepted. The new standard establishes minimum and maximum limits for helix angles, pressure angles, etc.

W. H. Himes, mechanical engineer, Westinghouse Electric & Mfg. Co., as chairman of the worm gear committee, submitted for discussion numerous proposed changes in worm gear nomenclature. The committee also is considering a series of tests as a basis for a recommended practice.

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In Prof. Martenis' article in the October issue the last ratio in the formula at the top of the left hand column of page 21 should read $\left(\frac{d_1}{d}\right)^4$. The line following the expression $M = \sqrt{B^2 + (KT)^2}$ should read, "$K$ being a constant to be determined," and lower down the column, in the formula for finding the value of $K$, the equation should read, $SZ = KS_1Z_1$.

# How Field Facts Help Sales and Design

By Chapin Hoskins

"I AM sick and tired of having you make use of our shop as a laboratory," wrote a user of conveying machinery to a manufacturer not long ago.

The machinery which this man's company had bought was expensive. It was fully guaranteed, and its maker proved faithful in living up to his guarantees. In its first day on the floor, the machine failed to perform properly. The maker's demonstrator, who was present to instruct the purchaser's employes in its operation, wired for a replacement of a small but important cam.

His friendly service re-established the user's confidence, but ten days later something else went wrong. The service man was sent quickly, in response to a long distance call; the adjustment was made ungrudgingly.

But after another lapse of time, another failure had to be reported. And before the year was out there had been a half dozen service calls.

In each case the maker—a company of high reputation—responded so promptly and so cheerfully that for a time the user of the machine almost felt as if a favor was being done for him.

Then suddenly, one day, he burst forth in the letter from which I quoted.

"In my opinion," the factory manager told me, "this manufacturer was just using us as a proving ground. His machine was designed by his engineers as they thought it should be designed, and they are among the most capable engineers in the country. But no matter how sound a piece of machinery may be on a blue print, no one knows what will happen to it in actual use until it has been through such use. Hereafter I shall buy my equipment from companies which send me a finished product and not a laboratory toy."

Carried to the extreme as it was in this case, the use of the customer's premises as a "laboratory" would certainly have few defenders.

But in a perfectly legitimate way, the customer's manufacturing plant, store or home, plays an important part and always will play an important part in the development of machinery.

You and your engineering department may

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*Fig. 1—Design changes invariably followed trials of early model cars. The illustration shows a 1904 model on a Mt. Washington, N. H., hill climb*

have a perfectly uncanny ability to design practical machinery in all its details. You may have a well equipped laboratory for testing everything from strength of materials to coefficients of friction. You may even have an elaborate and conscientious testing department, and you may delay the marketing of new models almost to the danger point (in the face of competition) rather than have them leave your plant insufficiently tried. But in spite of all these precautions, the machine which you have designed will, in the customer's hands, be subjected to tests that the most fertile brain could not possibly think of in advance. After all, the worth of any machine is determined by what it does in practical use. For the actual test of practical operation by a customer there is no substitute.

Do you remember the automobile that you or someone you know very well bought back in 1904? You had to change gears on the slightest provocation. You were always prepared to "get out and get under" at least once on every trip of 20 miles.

Yet from that wheezy contraption of 1904 has developed the magnificently reliable, comfortable and handsome piece of machinery which serves you so faithfully today.

### Development in Design Is Rapid

And all of this remarkable development in design has taken place with astonishing rapidity because motor car designers have gone to infinite pains to learn what happens to their product in the user's hands, what the user expects of his automobile and what they can teach him to expect.

Back in those days when a cross-country tour of 50 miles was quite an event, there were doubtless plenty of automobile makers who paid only secondary attention to what happened after a car left their factory door, or who treated customers' complaints as a nuisance. But it is a fair bet that the names of those manufacturers are not to be found among those who are active in the automobile world today.

### Detailed Test Information Valuable

From the days when Glidden tours gave progressive manufacturers a test for their product far harder than the measure of current demand and Henry Ford tested his own automobiles by racing in them, designers of motor transportation seem to have welcomed every opportunity to gain detailed information about the performance of their product in users' hands. Has the car you bought this year shown an imperfection of any kind? There is no one more anxious to know about it than its designer, and you can count on it that if the same weakness develops in a number of cases, it will not appear in next year's model. And the fact that the weakness developed at all is proof that there is nothing like use to test the results of use, for, almost certainly, the maker of your car spent many thousands of dollars in preliminary laboratory tests, and many thousands more in proving-ground and road tests of the finished model.

This policy of seizing every opportunity to learn what happens to your product in your customer's hands has by no means pervaded the field of machine design. The maker of that machine which caused the explosion of the customer who thought his shop was being used as a laboratory, is still living in the days when automobile manufacturers began to pride themselves on their

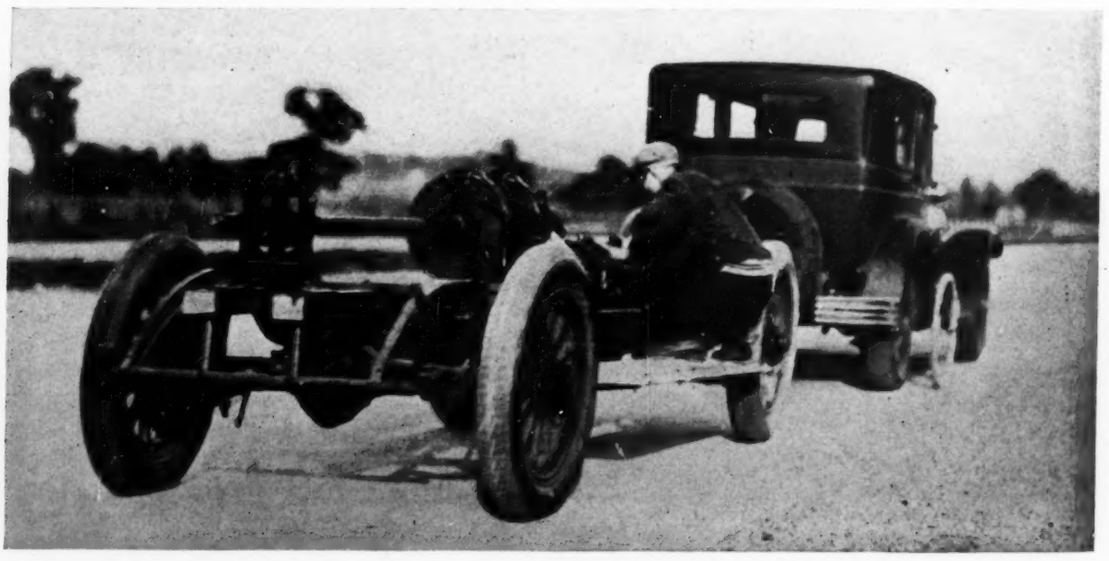


*Fig. 2—Dynamometer test of new car at proving grounds. This indicates efforts of manufacturers to locate design weaknesses before marketing products*

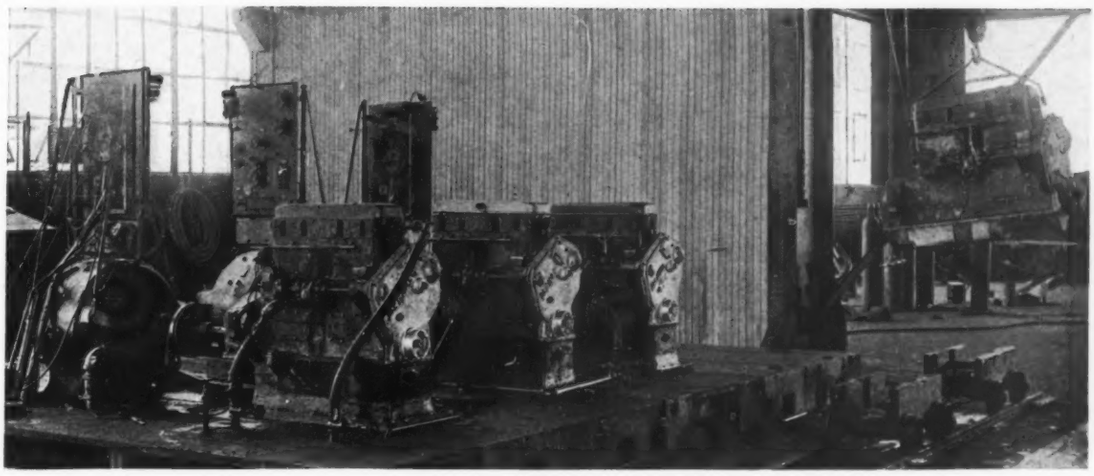


*Fig. 3—Marine engines on test block. Another example of thorough testing of newly designed product before it is placed on the market*

"service" but were in truth putting most of the expense of their testing onto the public. No one minded it then. Any one who could afford an automobile was glad enough to have it, defects and all. Today, however, the motor car designer who would permit any serious proportion of his experimenting to be at the public expense would not be found at next year's automobile shows. And judging by the way the idea of utilizing every opportunity to obtain information that will result in design improvement is taking hold of machine industries, the machine designer who does not follow this idea for all it is worth is going to be "out of luck."

### Investigation Covers Many Fields

Recently, at the suggestion of the editors of *Machine Design*, I have been making an investigation of the methods which makers of various types of machinery follow in gathering information about user-experience that will be of help to them in the improvement of their designs. We wanted particularly to find out how the actual facts of user experience are laid before the chief engineer (or whoever in any particular case is responsible for the product designed.) In making this investigation, I have purposely covered all degrees of machine complexity from the simplicity of an electric heating unit to the multiplicity and variety represented by the machine which folded this sheet of paper in the magazine now before your eyes. Similarly, we solicited information both from companies with a high reputation for the performance of their products and from companies of whose product we have now and then heard criticisms.

Perhaps the most interesting phase of the whole matter is that the makers of equipment known nationally for its reliable performance have disclosed well planned and well established systems for studying performance. Whereas companies of whose product we have personally heard complaints among users have been vague in answers, or indicated that a good hard "customer kick" is about their only source of performance information. In other words, the companies which most need to pay attention to this phase of the design problem are the very ones which are neglecting it.

Most companies are, of course, average. Few lead the procession and few fall to the rear.

Good old average performance seems to call for about just one item in the performance-study set-up. This is a blank on which a salesman or a "trouble shooter" may scribble his reports of a customer's complaint. If the customer is a pretty good fellow, and a salesman is holding the pencil, the report is liable to be scathing. If the customer is ugly and the service man is reporting, the filled out blank is more likely to discuss misuse of the machine than its defects.

I know one plant to which a good many such trouble blanks have been coming in the last few years. As each one comes the procedure is somewhat uniform.

The sales manager receives it first, and without waiting to open the rest of his mail, rushes into the office of the production superintendent.

### Sales Manager Is Belligerent

"Here is another rotten job you fellows have turned out," he explodes. "Look at this! . . . . .!"

From long experience, the superintendent knows how to calm the sales manager. He sends for the blue print of the job, and in an instant the difficulty is solved.

"O, yes, I remember this," he says, with a significant raising of his eyebrow. "Cast your

eye over this, George." And he launches into an involved criticism of certain small details of the design.

"I remember telling Joe at the time that this wouldn't work," is usually his last word on the subject.

With battle in his eye, the sales manager steps quietly but ominously into the chief engineer's sanctum. On the defensive but sincerely concerned by the failure of the equipment, the chief engineer sticks to his guns.

"Never mind what Bill says," is his advice. "That design is correct and I will show you why." And the problem is solved to his own satisfaction

agreed in ascribing the difficulties to "disappearing markets," but it is a fair guess that a good bit of the decline comes from that familiar "trouble blank."

The difficulty of course is not with the blank but with the way in which it is used. Unless the customer has a complaint, the design department of this company has no direct knowledge of the success with which its product serves users. In the customer's mind, the complaint is a grievance. This gives the sales department a grievance against either the production department or the engineering department—and it doesn't rightly know which. And in turn the

*Fig. 4—Walter C. White driving White steam car on 1907 Glidden Tour. Executives paid close attention to road performance with view to design improvement*

if not to that of the sales manager. "If you get to the bottom of this thing," is his usual closer, "I am going to bet you that you will find your customer is using his equipment improperly. If you fellows in the sales department would only realize—"

And so it goes.

Next comes an executive meeting in which the general manager and his assistants take a hand in an effort to fix the blame for the weakness which has developed. Strangely enough, wherever the blame lands, it never stays put.

Only the other day two business men of my acquaintance who met on a train, were asking each other why this particular company has not been getting anywhere of recent years. They

production and engineering departments generate a grievance. Sometimes directed at each other, sometimes focused on the sales department, and in any case making them feel that customers, on the whole, are full of strange conceits and peculiar notions about just what a piece of machinery should be expected to do.

Under such circumstances, it is pretty difficult to develop a constructive attitude that will result in constant improvement of design.

I should hesitate to consider this little drama as typical of what takes place in machine manufacturing plants. Yet it is I suspect more nearly typical than most people realize.

Here, for instance, is a paragraph out of a manual prepared last year for the benefit of the

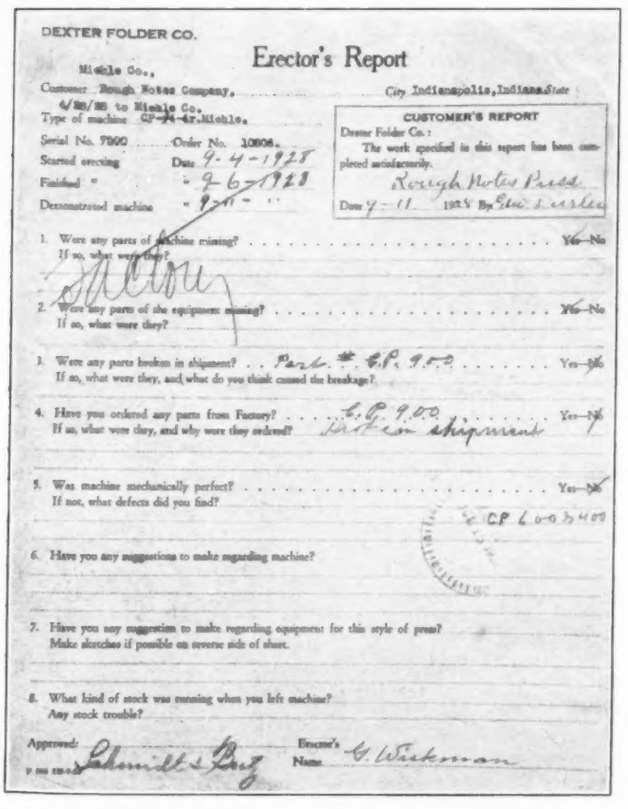
production organization of an important eastern manufacturing company. This particular paragraph was written by the manager of engineering. (In this case, the president of the company himself is the chief engineer.) The paragraph reads:

> "As the engineering department is now organized it has no responsibility after a product has been designed and turned over to the shop, unless the material does not function properly, either mechanically or electrically. At all times the engineer is responsible for design. As a general rule, an engineer is interested enough in a new product to keep more or less an eye on it for a while when it is first produced."

If this paragraph in the manual means what it says, it looks as if, in this company, progressive as it is in engineering design, no information about the performance of products comes to the design department unless it is the negative information sent in by a dissatisfied customer.

### Using Contacts to Advantage

An excellent example of a design-improvement system which makes use of "trouble sheets" in a positive instead of a negative manner, is that of Dexter Folder Co., makers of automatic paper-handling machinery. This system has been described for us by W. H. Vogt, of the company's



DEXTER FOLDER CO.

Erector's Report

Miehle Co.,

Customer Rough Notes Company, City Indianapolis, Indiana State

4/28/25 to Miehle Co.

Type of machine CP-44-42 Miehle.

Serial No. 7900 Order No. 10906.

Started erecting Date 9-4-1928

Finished " " 9-6-1928

Demonstrated machine " 9-11-"

CUSTOMER'S REPORT

Dexter Folder Co.:

The work specified in this report has been completed satisfactorily.

Rough Notes Press

Date 9-11 1928 By Elmer Sisler

1. Were any parts of machine missing? ... Yes No
If so, what were they?

2. Were any parts of the equipment missing? ... Yes No
If so, what were they?

3. Were any parts broken in shipment? Part # C.P. 900 ... Yes No
If so, what were they, and what do you think caused the breakage?

4. Have you ordered any parts from Factory? C.P. 900 ... Yes No
If so, what were they, and why were they ordered? Lost en shipment

5. Was machine mechanically perfect? ... Yes No
If not, what defects did you find?

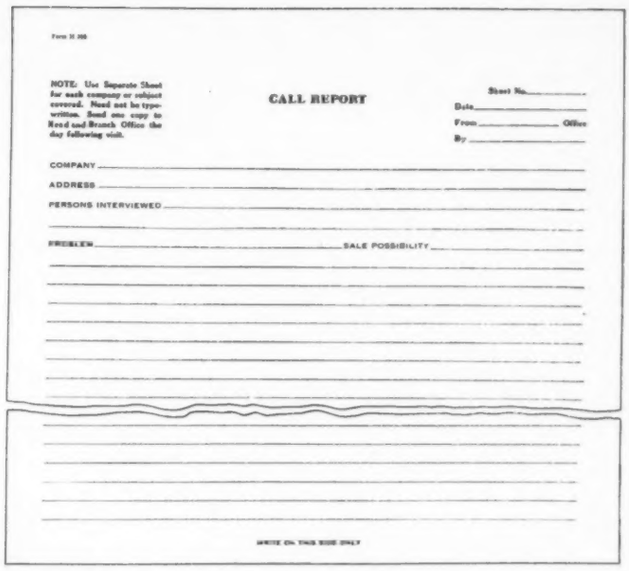
6. Have you any suggestions to make regarding machine?

7. Have you any suggestion to make regarding equipment for this style of press?
Make sketches if possible on reverse side of sheet.

8. What kind of stock was running when you left machine?
Any stock trouble?

Approved: Schmidt & Berg Erector's Name G. Wiskman

*Fig. 5—Each question on this up-to-date erector's report is vital*



NOTE: Use Separate Sheet for each company or subject covered. Need not be typewritten. Send one copy to Head and Branch Office the day following visit.

CALL REPORT

Sheet No.
Date
From Office
By

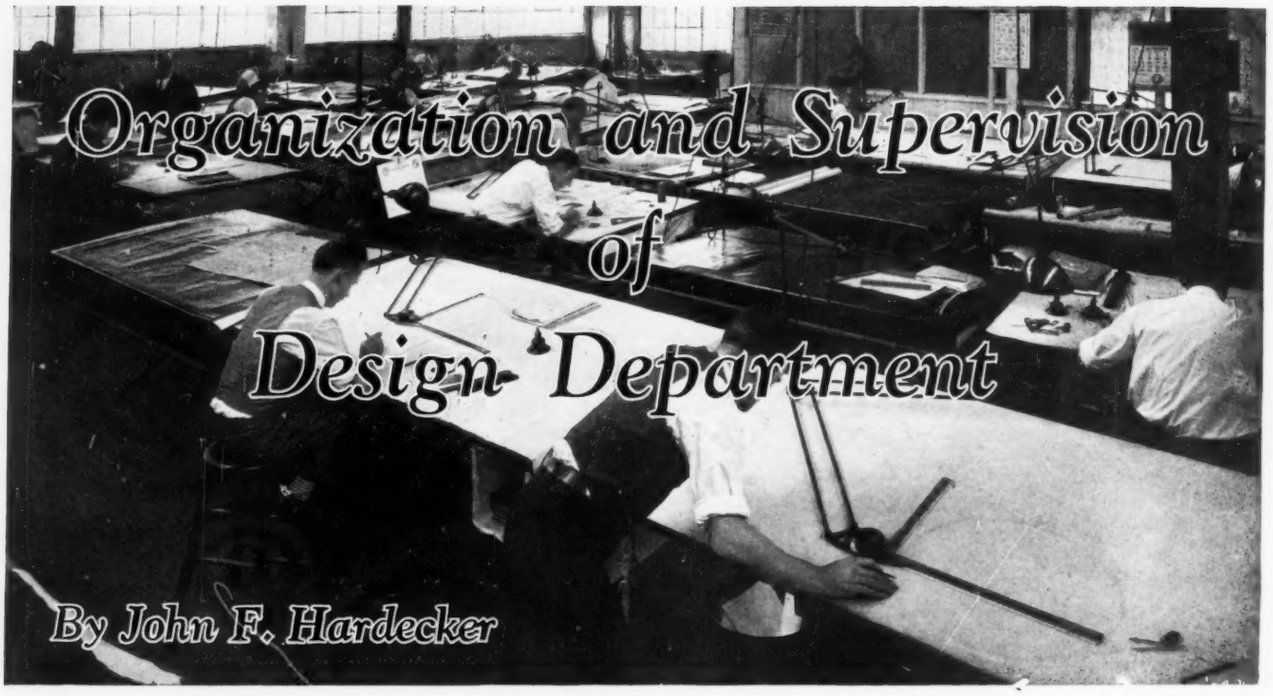
COMPANY
ADDRESS
PERSONS INTERVIEWED
PROBLEM SALE POSSIBILITY

*Fig. 6—One type of call report which might be termed a "trouble blank"*

engineering department, as follows:

1. After each installation is completed, our erector furnishes us with an erector's report. A photostat copy is attached, in which he enumerates: parts missing from machine, parts of equipment missing, parts broken in shipment, parts ordered from factory, was machine mechanically perfect?, suggestions relative to the machine, suggestions relative to the equipment for this style of press, and kind of stock run on the machine. *This information is carefully gone over by the engineering department and the necessary corrections or changes are made to take care of future installations.*
2. Our various branch offices keep us in touch with any trouble that arises in the field and this information is passed on to the engineering department. In many cases, the design of the particular part is changed and applied to particular machines giving the trouble, and *if our observation shows that the difficulty is overcome, we adopt it as standard procedure.*
3. We also obtain information from our general trouble man who covers the territory thoroughly and advises us of his findings and proposed solution of the trouble.
4. At various intervals during the year, erectors' meetings are held in conjunction with the engineering department, and at this time, various suggestions relative to interferences, changes in design, etc., are brought out, all of which tend to perfect the adaption of our equipment to the bindery.
5. At various intervals during the year, our different erectors visit the factory and furnish us with suggestions which help the engineering department to eliminate future trouble by the erectors themselves. In this way, the erectors are in reality the eyes of the engineering department in making installations as nearly perfect as possible.
6. When a new problem is met and a new machine is required, we arrange to have the designers themselves visit the plant and carefully study the problem. In this way, the conditions which have to be met are clear in the mind of the designer as he works up the new machine.

*(Concluded on Page 41)*



# Organization and Supervision of Design Department

By John F. Hardecker

**Part III**

## *New Orders—Collaboration with Sales Staff—Freedom of Designers—Production Department Contact—Contact with Field*

TO THOSE not intimately associated with the detailed development of design, it may appear that the order for a new machine design may be handled quite in the same manner in the design department as in the production shops. While there is a certain analogy, it must constantly be borne in mind that the instructions for shop work—namely the drawings of the engineering department—have been worked out in great detail and represent the well thought out, co-ordinated and finished work of many technical minds. On the other hand the order for a new design of machine may express only the idealized wish of an individual, generally incomplete, and often vague and incoordinated.

In many cases the order is given and accepted by those who themselves have no detail function in carrying out these designs, but only a happy confidence in the ability of a design department to accomplish any job. Very often, while the individual features of a new design are each possible within themselves, it is utterly impossible to carry them out in combination. This means compromise—not necessarily immediate—but only after considerable detail study which will unearth the best general solution, retaining the most significant of the desired features. Not only must there be compromise on the design features from a technical viewpoint, but often that which is possible on paper is prohibitive in cost in the shops.

### Design May Involve Established Features

There are obviously design organizations where a new design may only involve some new combinations of already established design features, or the application of the existing features to new sizes, capacities, speeds, etc. Such designs may be handled advantageously as a design production job, following a logical drawing up of parts in regular sequence and ending with inked tracings without deviation from routine system. This, of course, is idealized design, per-

*EFFICIENCY in handling new orders is an important factor in any modern engineering department. In the accompanying article—the third of Mr. Hardecker's series—the author makes many suggestions regarding basic design work. He also points out how contact with the sales department, the production department and the field can prove a valuable asset to the designer and assist him materially in his accomplishments.*

fectly feasible where applicable, but the danger lies in a too ready acceptance of this procedure, and a failure to recognize that a basically new design necessarily cannot be made to follow this straight line routine efficiently.

Most new designs present some unusual and original new problems in some phase of their design. To follow the line of least resistance and detail the standardized or accepted features first, leaving the real problems to the last because it makes a good showing to state that in terms of total number of completed drawings the job is already 75 per cent complete in a few weeks, is not good design management. It is far better to have no completed drawings at the end of the equivalent time, and have all the unusual features successfully schemed out and sketched. While it may at first hand appear appalling to face the fact that after several weeks' work of a group of design personnel, there is as yet not even one finished drawing, it argues well for the ultimate success of the job provided the time has been conscientiously spent in studying the new features of that design.

### Several Solutions Are Possible

It should be kept foremost in mind that there are many ways of solving any given problem. Discounting the unsatisfactory solutions, there are still several solutions—a good way, a better way and the best way. The man who completely details his first idea in terms of a finished drawing, is not really saving time, but rather wasting it, for it is hardly likely even though he hits on a good idea that he will get the best idea on his first trial. Therefore five or six sketches of different possible solutions made in less time than a completely detailed set of drawings of one possible solution are a far greater economy in the long run. Due to the past training of certain designers and draftsmen, it is sometimes difficult to carry out this idea without constant check up to see that they are not trying to save time as they see it, by immediately developing fully their first idea.

### Number of Lines No Criterion

In this regard, the number of lines on a sheet of paper or tracing cloth is not a measure of good draftsmanship, except possibly for the tracer. Too many draftsmen unfortunately believe that the amount of lead they can get on their drawing surface is a measure of their success. In the ramifications of design inherent in the development of a new machine design, it is essential that approval of ideas be obtained as expeditiously as practicable. Suggested changes often can be incorporated readily if made after the tentative study of each problem, which if deferred, will seriously interfere with the design work done on other parts based on the assumption that the preceding layout is correct. Therefore, it is essential that as far as possible approval be obtained immediately on each step as the design progresses. This may entail either local or customers' approval.

In many large organizations handling a variety

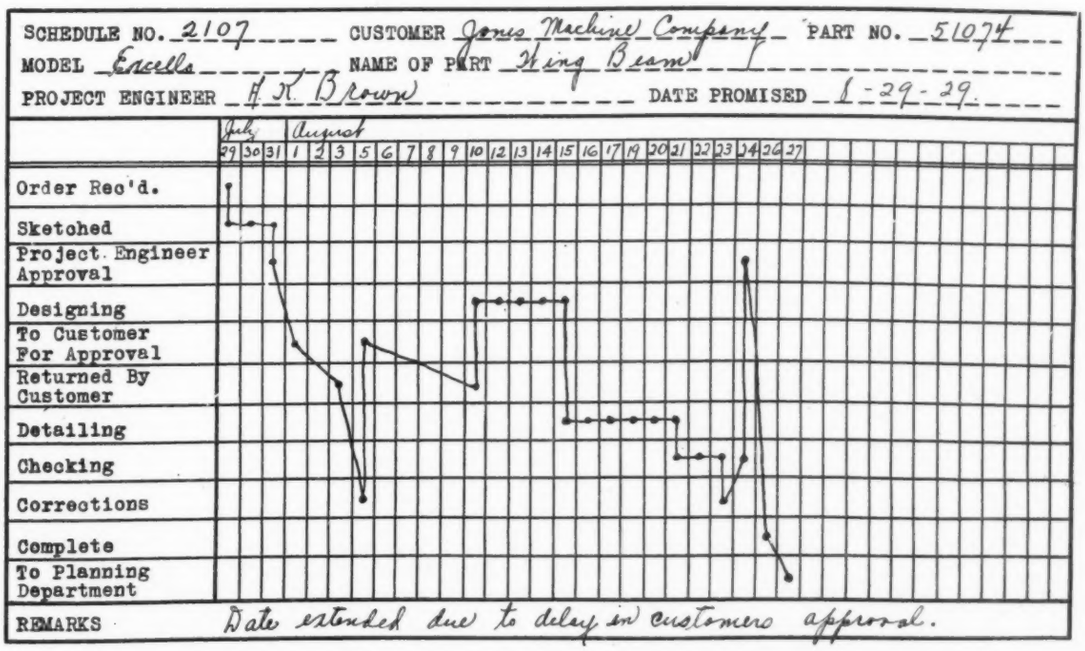

SCHEDULE NO. 2107 CUSTOMER Jones Machine Company PART NO. 51074
MODEL Excello NAME OF PART Wing Beam
PROJECT ENGINEER H. K. Brown DATE PROMISED 1-29-29
July
August
29 30 31 1 2 3 5 6 7 8 9 10 12 13 14 15 16 17 19 20 21 22 23 24 26 27
Order Rec'd.
Sketched
Project Engineer Approval
Designing
To Customer For Approval
Returned By Customer
Detailing
Checking
Corrections
Complete
To Planning Department
REMARKS
Date extended due to delay in customers approval.

*Fig. 1—Type of card used to keep close track of job and avert delays*

of new designs for various customers, it may become necessary to use some form of card to record the progress of the different jobs, so that information is on hand at all times as to the progress, and delays can be averted by proper follow ups when they threaten. Such a system should be simple enough so that it can be handled by any ordinary clerk, who will obtain most of the information from readily available sources such as time cards, correspondence records, etc.

### Schedule Form Is Useful

A typical card which shows the progress of work graphically is given in Fig. 1. It is believed this is self explanatory. As previously stated, this may become necessary in certain large organizations, but it is not to be assumed that it is of necessity desirable in all engineering departments.

There is one phase of design development that is often overlooked in the development of a new design, and that is early collaboration with the sales department. While it is true that salesmen are not necessarily designers or engineers, they are nevertheless in intimate contact with the sources of information not otherwise known to the designer. For example, a certain feature of design used by another manufacturer may appear perfectly feasible from a design viewpoint for the new machine, yet the salesman by intimate contact may be aware of certain operating objections to this feature, which makes it highly undesirable. Again the salesman may know of certain peculiar restrictions of operation, material or process, which have not been brought out in the original specification for the machine, and yet which should be duly taken account of if the new design is to be fully successful. The time, of course, to find these things out is at the inception of the design, and not after the machine is designed and built. The main point is to utilize the contact information of the salesman, but at the same time not to lose sight of the fact that the responsibility is still the designers. A little tact properly exercised, will readily enough accomplish this.

To extend to project engineers or other design leaders full freedom as to their movements, thoughts and characteristics, is highly desirable. Essentially, theirs is a peculiar mental responsibility, which is not in any sense to be measured or controlled by any means comparable to those used for instance in a production shop. In certain organizations, on the plea of democracy and equality, they have been put on the time clock, subject to the same penalties for lateness, etc., as have other employes. This generally has been a mistake, for normally a good design leader works many more than the prescribed hours on his job, getting in early, working late or taking home work when the occasion demands. Therefore, when he finds it more convenient to start later some particular morning, with full intentions to stay well beyond the regular time at night, or to leave early some afternoon because of a temporary lull in his work and attend to some long neglected personal business, the time clock reacts on him like a red flag does to a bull.

*Fig. 2—View of engineering department of modern plant, showing orderly arrangement, good lighting and ample space provided.*

### Restrictions May Mar Progress

It is more advisable not to put any routine restrictions on the design leader's time, but merely expect him to observe the general hours of the office, for in this way he will invariably give many more than the total hours officially exacted in a year, and at the same time govern them in accordance with the demands of his work.

His movements about the plant, field contacts, etc., should not be restricted, but left to his own judgment. The only restrictions should be that he keep in contact with his office, advising by

telephone if necessary of his movements, so that he can be reached readily in case of an emergency or other urgent need. Under certain conditions, it may be advisable to establish office hours, to reduce the lost time of other personnel who must seek contact with him.

The design leader should be left reasonably free to develop his own ideas and thoughts. An ultimately splendid design idea may be very hard to sell in its embryonic state, and if continually hampered in its development by demands for explanations, the design leader may abandon it before it is completely developed. It always must be recognized that at its inception, a new design may be the merest germ of an idea, and to expect the project engineer to thoroughly justify it in all its details before he has had a chance to work it out, is both unjust and unreasonable. On the other hand, if the project engineer is intent on developing a phase of design which is impractical and in the judgment of those responsible for policy devoid of commercial possibilities, there should be no hesitancy in requesting that he abandon that project.

Just as there are many methods of approach and attack in solving any given problem, so too, there are very likely to be differences in personal characteristics of individuals who possess the imagination and initiative to function as design leaders. Just as long as these characteristics, peculiar though they may be to some observers, do not interfere with the functioning of other personnel, they should be unrestricted. Design leaders cannot be expected to possess standardized characteristics, for they are in no sense cast from the same mold.

If however, these characteristics interfere with the work of others, they should be subject to corrective measures. I have in mind here the project engineer who in disapproving the tentative design of a draftsman says in effect, "I don't like that. Show me something else and see if I like that better." Such tactics, while rare, have been known to be used on occasions. In such instances, the design leader should be called to task, for he should at least give some indication of the type of design which will meet his approval.

### Production Department Should Be Consulted

Not only should design personnel have full opportunity to maintain unrestricted shop contacts at all times, but it is usually desirable to call in factory production department personnel for consultation during the development of a new machine. Suggestions thus received often mean considerable savings in ultimate shop costs when the design reaches the manufacturing stage. In his intent desire to evolve a successful technical design, the designer may often prescribe a design feature which is very impractical from a shop production viewpoint. The production man brings to the problem a practical slant, which if rightly fostered and utilized, is of real value.

### Copartnership in Design

Again, a particularly difficult piece of machining, highly desirable from a design viewpoint, may upon release to the shop come back with a request for redesign, based on the quickly formulated reaction that it can't be done. Yet, if the production personnel has been called in when the design was developed and asked for criticism of the design and the particular feature pointed out to them as highly desirable, it is most likely that they will feel in honor bound to make good in its production. When consulted, factory production heads feel a copartnership in the design, and will lend every effort to putting it across. When they are ignored in the design, and see it for the first time in the form of a production drawing with an order attached, they are likely to react with antagonism to what they believe an unreasonable design.

No one knows more intimately the details of a new design than its designer. Therefore, when experimental trials are undertaken, no matter how competent the personnel assigned to such tests may be, they are not in as good a position as the designer to analyze the flaws or weaknesses developed. It is one thing and an obviously useful function, to record the details of an experimental trial, but it is quite another thing to, at the same time, interpret the intimate details of that design which are responsible for weaknesses or undesired characteristics.

If the designer is not present certain useful observations essential to the peculiarities of a particular design may not be recorded. Again by his presence the designer may avoid certain abuses of the design in its trial, which would lead to its destruction, or which would inadvertently have a decidedly injurious effect. The test personnel, following either prescribed instructions or standardized procedure, may not recognize the need for special handling or operation peculiar to the design in hand, and not previously recorded. This is particularly true in moving machinery, where experimental machines may have to be gradually run in. In structural strength tests to destruction, the project engineer may observe that a certain point is weakening and is destined to be the point of failure. Immediately he can by his intimate knowledge of

the design, cause this to be strengthened with the result that the tested member may carry many more increments of load, and give a true ultimate failure. Without his presence, the member may have broken prematurely at the weakened detail, with the result that an entirely new test member, reinforced at this point, would have had to be built and retested.

### Facilities for Field Contacts

In some organizations, it may be felt that the designer's place is essentially in the engineering department, and that one machinery exposition or show of his particular industry a year, is all the field contact he needs. This is a mistaken impression, for only by real contact with the field can he gain that broadened experience which is productive of real design improvements. The designer's membership in the engineering societies of his particular field of engineering is worthy of encouragement, both moral and financial. It is not unreasonable to permit him to attend the annual sessions of such a society on the company's time and at the company's expense. Contact with fellow engineers and designers acts as a stimulus to his wits, broadens his vision and brings to his immediate job a vigor that pays real dividends on the investment.

Within the scope of his own immediate field of operation, he should be encouraged to visit the plants where his designs are to operate, as well as those where his actual designs are installed and operating. It is chiefly through such contacts that he can attain that refinement of design which spells the difference between a merely good design and the best that can be evolved at the current stage of development of his industry at the time the design was made.

# Unbalanced Pressure Necessitates Redesign

SOME time ago, in the design of a machine we were building for a customer, it was necessary to supply steam at 200 pounds per square inch pressure, from stationary steam piping to a revolving double acting steam cylinder. The arrangement, as specified by the customer, was as shown in Fig. 1. Steam was supplied through a suitable control valve to pipe openings *A* and *B*, from which it flowed through the ports and channels illustrated to one side or the other of the piston, as regulated by the control valve.

This design was a failure as the unbalanced pressure, acting on the end of the swivel pipe *C*, caused excessive wear at that point.

To overcome this, a new design was made as shown in Fig. 2. Steam pipes from the control valve are connected to pipe openings *D* and *E*, from which the steam flows through the ports, channels and lantern rings *F*, as illustrated, to one side or the other of the piston, as regulated by the control valve.

The new design was a complete success and as all the pressures are balanced, no end thrusts are present. The set screw *G* is provided to keep the steam connection from floating lengthwise. The steam connection has a lengthwise wall which separates the channels leading from openings *D* and *E*.

S. B. GORBUTT, Chief Engineer,
*Willamette Iron & Steel Works,*
*Portland, Oregon.*

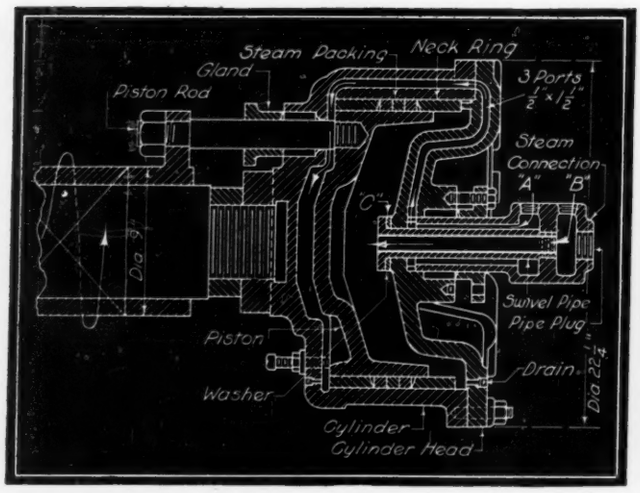



*Fig. 1—Design failed due to wear at "C"*

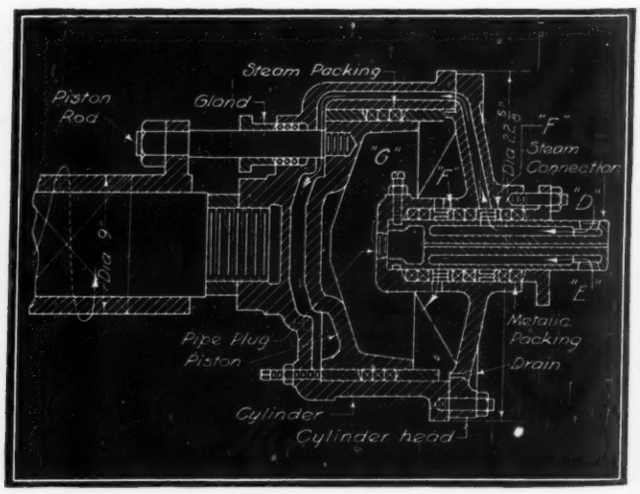
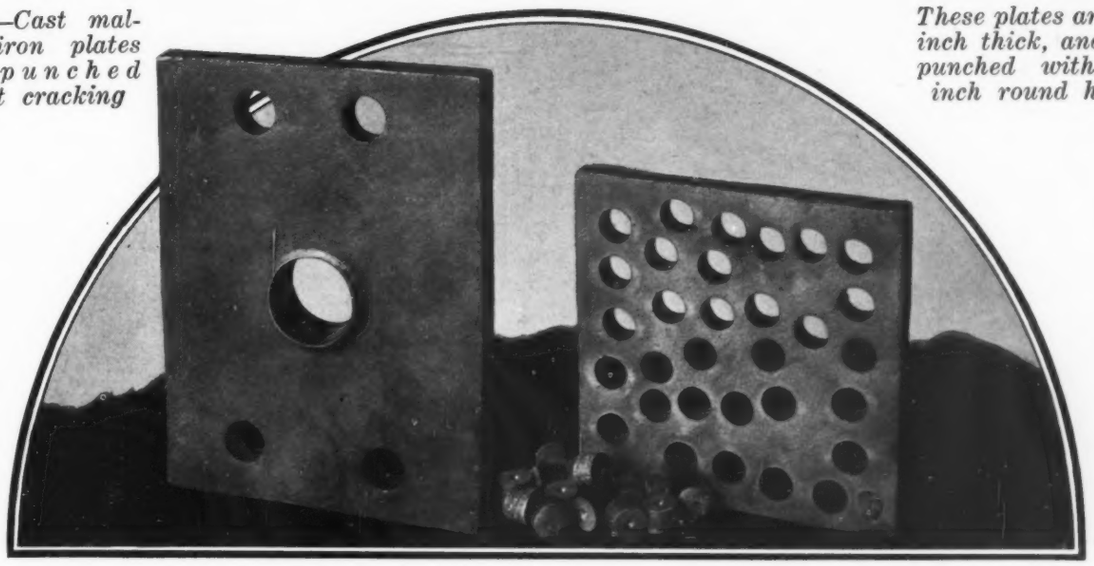



*Fig. 2—This redesign eliminated difficulty*

*Fig. 1—Cast malleable iron plates can be punched without cracking*



*These plates are 5/8-inch thick, and are punched with 5/8-inch round holes*

# Malleable Castings Offer Many Possibilities to Designers

By Joseph B. Deisher

TODAY, when luxuries of life may be had by pushing a button, throwing a switch, or shifting a lever, seldom does the average individual pause to realize how much modern civilization owes to the machine designer. Through his brilliant and never-ending achievements, transportation facilities have conquered time and space; means of communication bring daily to our firesides the news of the world; and, by diverting human energy into more productive channels, he has brought to the worker not only the necessities of life but many of its luxuries, and spare time to enjoy them.

With the increasing demand upon the machine designer for better machines at a reasonable cost he is confronted with the important problem of selecting the most reliable and economical materials for machine construction. Along with many other materials, malleable cast iron has within the past few years enjoyed a marked improvement in quality; and, to place in the hands of the designing engineer reliable and up-to-date information concerning malleable iron castings, the following data are given:

Malleable cast iron is a cast material with ductility closely approaching that of wrought iron; can be cast into intricate shapes, varying in cross-section from 1/16 inch to 3 inches, in weight from the fraction of an ounce to 1000 pounds, in length from the fraction of an inch to six feet; machineable at high cutting speeds; can be punched or broached cold; more rust resistant than most other ferrous metals; withstands shock; has high yield point and elongation; casts with smooth surface and takes excellent coating or finish. A remarkable cast material for light and medium sections, where service demands maximum strength for minimum weight.

### Tensile Strength and Elongation Are High

Based upon intimate knowledge of the product of about seventy malleable foundries in the United States, the writer is in position to state that the average ultimate tensile strength per square inch for their entire production is in excess of 53,500 pounds, and average elongation in two inches is in excess of 17.5 per cent. The American Society for Testing Materials specification for malleable cast iron calls for a minimum of 50,000 pounds ultimate tensile strength per square inch and 10 per cent elongation in two inches.

The average yield point for product of the foundries just mentioned is in excess of 36,500 pounds per square inch. The A.S.T.M. specification for malleable cast iron calls for a minimum yield point of 30,000 pounds per square inch, which at the suggestion of the malleable manufacturers can now be increased to 32,500 pounds per square inch.

Inasmuch as the yield point determines the service capacity of a casting, an interesting characteristic of malleable cast iron is that the yield point is approximately 65 per cent of its ultimate strength, which is a higher ratio than obtains in most other ferrous castings.

The machineability of a malleable casting is one of its economic virtues. It is generally conceded by machine shop authorities that when compared with machining other materials of similar strength there is a remarkable saving in speed of machining as well as in labor and tool cost.

*THIS is the third of a series of articles covering, from the viewpoint of the designer, various phases of the application of castings and materials to machine construction. The author is one of the leading authorities on malleable iron castings. His business activities include 16 years spent in the malleable iron foundry of the Symington Co., Rochester, N. Y.; three years as assistant consulting engineer of the American Malleable Castings association; a period in Europe on consulting work for the American Radiator Co.; two years as an independent foundry consultant, and from February, 1929, until recently as engineer for the Malleable Iron Research institute. On Nov. 1, he became works manager for the Columbia Malleable Castings Corp., Columbia, Pa. He is a member of American Foundrymen's association and representative for the malleable division on advisory committee to bureau of standards, department of commerce, Washington.*

Removal of the surface of a malleable casting, by machining, has practically no effect upon its strength, yield point and elongation.

Internal stresses resulting from uneven rate of solidification are removed to a greater extent than in any other form of castings, on account of the long slow temperature of annealing.

Due to the low manganese content and finely distributed graphite in the ferrite matrix, malleable cast iron will withstand rust and corrosion to a considerable extent.

It has also excellent shock resisting properties, and castings can be distorted into unbelievable shapes without fracture. A cast test wedge, one inch wide by six inches long, ½-inch thick at the butt tapered to 1/16-inch at thin end, can be curled its entire length by successive blows from a 70-foot-pound drop hammer, from 20 to 30 blows being required.

Malleable cast iron is not embrittled by fatigue or shock.

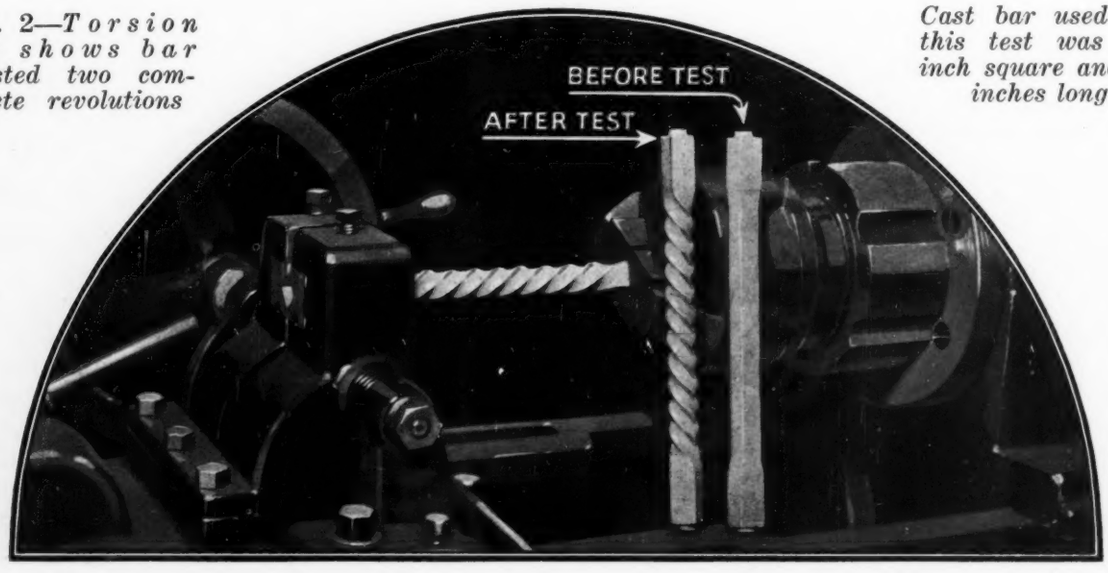
The ductility of malleable cast iron is shown in Fig. 2, illustrating how castings may be twisted or bent without fracture.

In the torsion test shown, a cast bar ¾-inch square by 12 inches long is twisted more than two complete revolutions.

The ductility of malleable castings not only prevents breakage of machine parts in transit or service, but often facilitates assembly operations by making possible minor adjustments in fitting parts without the necessity of extra machining operations.

Ductility also makes possible the forming or bending of certain parts of a casting to eliminate other more expensive means of securing various

*Fig. 2—Torsion test shows bar twisted two complete revolutions*




*Cast bar used for this test was ¾-inch square and 12 inches long*

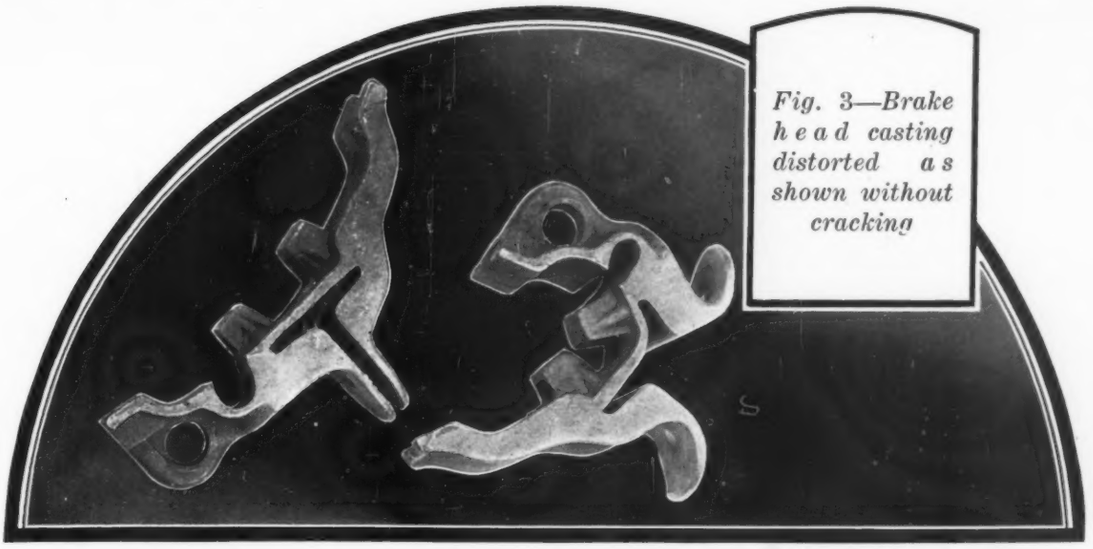


*Fig. 3—Brake head casting distorted as shown without cracking*

members in the assembly of machine parts.

The ductility of malleable cast iron also permits cold punching or broaching, which often saves more expensive finishing operations. Fig. 1 shows cold punching of 5/8-inch round holes through 5/8-inch cast section. Note the close proximity of punched holes without the least sign of cracking or tearing.

### Clean Surface Is Obtained

Castings can be poured at a comparatively low casting temperature, resulting in a smooth surface and one that is ideal for coating or plating. It also takes a fine finish on machined surfaces and for this reason often is used to replace parts formerly made of more expensive metals.

Malleable cast iron has greater fluidity for pouring and can be successfully cast into thinner and more intricate sections than is possible with other cast materials of equal strength.

In designing malleable castings, attention is called to the fact that increased section does not always give corresponding increase in strength. In this connection, the foundryman is neither qualified nor has any desire to tell the machine designer how his castings should be designed; however, after the plans are put on paper and before the pattern is made and gated, he can often call attention to minor details which will greatly simplify the method of molding and in many cases increase the strength of the casting.

### Present and Potential Uses

Space does not permit giving a detail list of the present uses of malleable castings further than to state that the largest tonnage goes into the automotive industry, including tractors and trucks, and also into railway equipment and accessories, road-building machinery, farming machinery, builders' hardware, electrical equipment, textile and shoe-making machinery; in fact, into miscellaneous parts of practically all machinery where strength and integrity of castings are essential.

Among the new uses for malleable castings are the substitution for more expensive metals; radio parts; track-plates for highway railroad crossings; braces for reinforcing telephone poles that have rotted at ground level; replacement of parts where extensive machining operations are necessary; street-markers; man-hole covers and street drains; highway markers and guard-rails; etc.

The total tonnage of malleable castings produced in the United States this year will approximate 1,000,000 tons.

### Research and Standardization of Quality

In these days when research is so rapidly changing the ways of industry, the manufacturers of malleable cast iron are doing their part.

About 15 years ago a concerted effort was started by a group of malleable iron foundries to establish definite and reliable physical specifications for malleable cast iron, and through cooperative research to place the manufacturing processes under scientific control so that the machine designer and engineer might have some legitimate assurance upon which to base his confidence in the consistency and integrity of malleable castings. Out of this effort grew the American Malleable Castings association, which organization did valuable pioneer work in improving the general quality and soundness of malleable castings, and later the Malleable Iron Research institute, which now carries on research

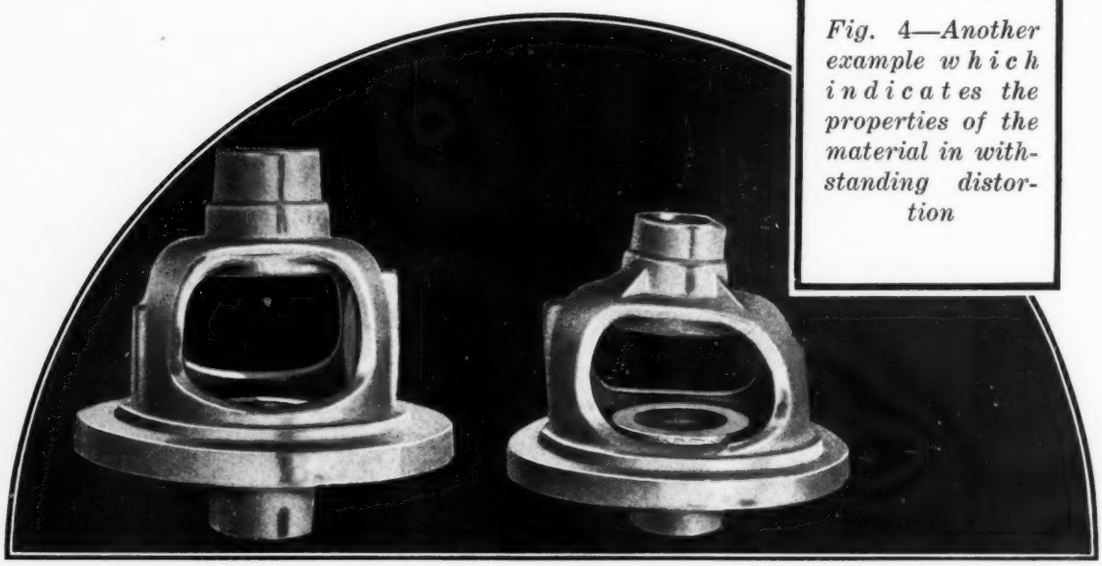


*Fig. 4—Another example which indicates the properties of the material in withstanding distortion*

work of a highly scientific character for about seventy malleable iron foundries in the United States.

The Malleable Iron Research institute has had for many years a consulting engineer who is constantly working to maintain and improve the quality of malleable castings, and they now have a practical inspection engineer who devotes his entire time to inspection and shop practice problems among the member foundries—his duties being parallel to those of a customer's inspector, with full power to refuse the "Certificate of Quality" which is regularly granted to those members whose quality of castings regularly passes the tests and meets the inspection requirements of these two independent engineers.

### Quality Has Improved

As a result of cooperative research, the American Society for Testing Materials has, at the request of the malleable manufacturers, increased from time to time its specification for malleable cast iron from 38,000 to 50,000 pounds ultimate tensile strength per square inch, and elongation from 5 per cent to 10 per cent.

The improvement made in the quality of malleable castings, resulting from research and improved methods of manufacture, has far exceeded the amount of educational work that has been done to keep the machine designer and engineer well posted on the properties of a material that has many unique and economic advantages.

Realizing the enormous responsibility that rests upon the machine designer in selecting the safest and most economical materials for machine construction, he should be impressed by the fact that about 400,000 tons of malleable castings are used annually in automobile construction and that one of the world's largest manufacturers of automobiles returned to the use of malleable castings recently after having tried another substitute material. There are few machines that are subjected to more abuse in service than the automobile; there is no other machine to which human life is more constantly entrusted, and there is no other type of transportation in which the accident rate is lower resulting from failure of construction materials.

The executive offices of the Malleable Iron Research institute are located at 2013 Union Trust building, Cleveland. As previously stated, this organization is constantly engaged in conducting malleable cast iron research, and machine designers and engineers may look to and rely upon its resources to furnish reliable and accurate data pertaining to the manufacture and uses of malleable castings.

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## Steel Founders Elect Officers

Officers were elected and a new plan of organization was outlined at the meeting of the Steel Founders' Society of America held at Hotel Sherman, Chicago, Oct. 29 and 30. Announcement of officers elected for the ensuing year is as follows:

President, J. E. McCauley, Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.; vice presidents, W. H. Worrilow, Lebanon Steel Foundry, Lebanon, Pa.; John E. Galvin, Ohio Steel Foundry, Lima, O.; Arthur Simonson, Falk Corp., Milwaukee; and E. H. Cornelius, Oklahoma Steel Castings Co., Tulsa, Okla.

# Study of Fatigue of Metals Yields Data for Machine Design

By F. H. Moore

*Research Professor of Engineering Materials, University of Illinois*

*DURING the years in which the fatigue of metals has been studied systematically, many facts in connection with the behavior of steel and nonferrous metals have been unearthed. Many of these have an important bearing on machine design and for that reason engineers and others dealing with materials for machine construction should be informed on the status of the investigations of fatigue. The results of this ten-year period of research were summarized in a paper presented at the meeting of the American Iron and Steel institute at New York, Oct. 25. The author, H. F. Moore, is research professor of engineering materials, University of Illinois, Urbana, Ill. In the accompanying abstract taken from that paper, the editors of Machine Design have included only such portions as are of direct interest to engineers engaged in design.*—THE EDITORS.

IN 1920 an investigation on the fatigue of metals had just been started at the University of Illinois. At that time there was no certainty whether there was any such thing as a definite fatigue limit for metals, below which metals could withstand an indefinite number of repetitions of stress. The great importance of localized stress at fillets, holes and grooves, in its effect upon fatigue strength, had begun to be recognized. The name "fatigue" had come into quite general use for denoting the rather mysterious action which led to sudden failure of metals under oft-repeated loading.

In the period which has followed, a great deal of study has been given to the problem of fatigue of metals. Many tests have been run involving 100,000,000 cycles of stress. Several tests have been run involving 1,000,000,000 cycles of stress or more. As a result, all these tests have proved that for practically all metals there is a limited stress below which the material can withstand infinitely large numbers of repetitions of stress without fracture. This limiting stress is called the endurance limit or fatigue limit. It usually is determined from a diagram plotted with stress as ordinates and number of cycles of stress necessary to failure as abscissas. Such diagram is known as an S-N or stress-cycle diagram. The obtaining of evidence for the existence of an endurance limit is one of the two major contributions which American laboratories have made to the study of the problem.

The determination of endurance limits by long time tests is a slow and costly process. Usually six specimens are required to obtain data for an S-N diagram and the tests take from a week to ten days to finish. Figs. 1 and 2 show two of the dozen or more machines employed in fatigue testing. Fig. 1 shows in diagram a testing machine for subjecting a specimen to cycles of reversed bending in which the specimen remains stationary. Fig. 2 shows a machine especially designed for testing specimens of thin flat material.

One of the most striking phenomena observed during the past ten years of study is the raising of the endurance limit of metals by subjecting samples to a large number of repetitions of stress just below the original endurance limit. Materials vary widely in their response to this under-stressing or "teasing" treatment, and, contrary to expectation, ductility does not seem to be a determining factor. For example, cast iron can have its endurance limit raised a much higher percentage by "teasing" than can brass.

On the other hand, stresses above the endurance limit seem to start fatigue cracks and to reduce the endurance limit of metal. In tests of car axle steel at the University of Illinois, stresses above the endurance limit were applied until a visible crack had developed to a length of about one-tenth of an inch on a 1-inch speci-

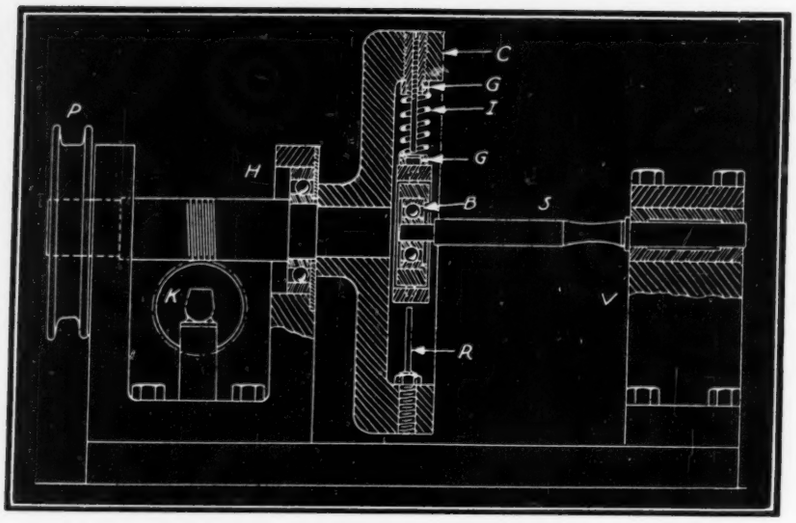


*Fig. 1—Machine for subjecting specimen to cycles of reversed bending*

*One end of the specimen S is held rigid in the vise V, and the other end, which runs in the bearing B, is rotated in a small circle. Sidewise pressure is brought on the bearing B by a calibrated indicator spring I. The compression of the spring, and hence the load and the bending moment, on the specimen, is measured by means of a strain gage spanning the gage holes GG shown near the ends of the spring. Sidewise motion of the bearing B is prevented by swinging the bearing on a pivoted arm and excessive displacement after the specimen breaks is prevented by the rod R. The chuck C is driven by a shaft H, a pulley P and a motor not shown. The number of revolutions is measured by a counter K*

men. The endurance limit of specimens so cracked was somewhere between 50 and 65 per cent of the original endurance limit of the metal. Understress raises the endurance limit, overstress lowers it, and here is seen another argument for the gradual "breaking in" of machinery.

### Localized Stress in Machine Parts

An outstanding development from the study of fatigue of metals concerns itself with the importance of localized stress. By localized stress is meant a stress which is not computed by the ordinary formulas of mechanics of materials, and which affects only a very small area of metal. Localized stress is found at the roots of screw threads and fillets, at the base of notches, and at holes drilled in a machine member. Under static loading, localized stresses do not affect the strength of ductile metals in any appreciable manner, but under repeated stress they frequently became nuclei for the start of spreading fatigue cracks. The study of localized stress has led to the rather startling fact that, for such stresses, our old theory of elasticity seems to be seriously in error. Localized stresses affect pure metals, and strong, fine-grained metals much more than they do coarse-grained metals of mixed structure, while according to the theory of elasticity all materials should be affected alike. The fine, heat-treated alloy steels are all sensitive to the effect of localized stress, while a metal like cast iron is practically not affected at all. All metals, however, are less affected by a given localized stress than is indicated for those cases for which we have mathematical formulas for determining the localized stress. It seems that, if we consider an extremely small area, the assumption of the theory of elasticity, that materials are homogeneous and indefinitely divisible without change of properties, becomes markedly in error. However, the results of fatigue tests of speci-

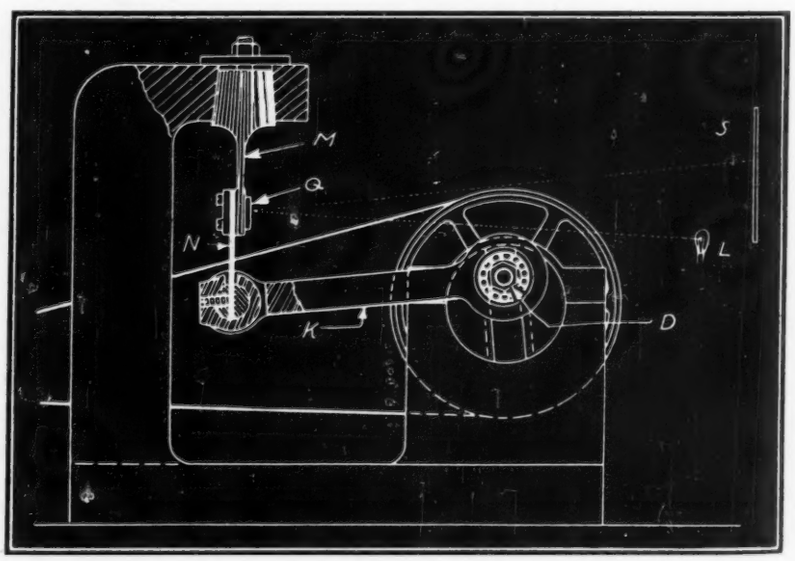


*Fig. 2—Machine designed for testing specimens of thin flat material*

*The specimen N is fastened at one end to calibrated flat spring M, and the other end of specimen is vibrated back and forth by connecting rod K, which is operated by variable-throw crank D. If the throw of the crank is increased, the bending moment on the specimen is increased, and the deflection of Q, a mirror attached to the calibrated spring, is also increased, causing motion of a beam of light reflected from lamp L to screen S. There is provided an automatic trip which is operated by dropping of connecting rod K when the specimen breaks, thus stopping the machine. A counter is provided for recording the number of revolutions*

mens with holes and grooves show that the theory of elasticity always is on the safe side.

One of the striking developments of the last ten years has been the widespread use of heat treatment of steel for the purpose of developing a stronger material of construction. It is possible by suitable heat treatment to triple both the static strength and the fatigue strength of high-carbon and alloy steels. The advantages of certain alloy steels seem to consist in their readiness to be benefited by heat treatment under shop conditions. Under controlled laboratory conditions plain carbon steel can be made practically as strong as any alloy steel but the ranges of temperature used and the technique of the heat treatment must be precise.

### Heat Treatment Changes Condition

In some cases, the change in crystalline condition of plain carbon steel is so rapid that only comparatively small pieces can be effectively heat treated. In the case of alloy steels, satisfactory heat treatments can be obtained with a wider range of temperatures and less closely controlled technique than is the case for plain carbon steels; and slower change of crystalline condition makes possible an increase in size of piece which can be effectively heat treated.

In all steels, and probably in all other metals, whenever a heat treatment or other treatment improves the strength of the material it also makes the material more sensitive to the damaging effect of localized stress. "Stress raisers," such as grooves, screw threads, and fillets, affact the fatigue strength of high-strength material by a much larger percentage than they affect the strength of low-strength material. High-strength material is not only stronger but it is also more "tender" and susceptible to injury, and must be handled very carefully by the designer and the machinist.

In 1926 D. J. McAdam, Jr. of the Naval Engineering Experiment station at Annapolis, noted that steel fatigue specimens exposed to a stream of water during tests failed at stresses much below those of specimens in the air. He found on examination evidences of corrosion and named this effect corrosion-fatigue. Somewhat earlier, Parr at the University of Illinois had noted the curious and rather startling failure of boilers supplied with certain feed waters of quite high purity. Later he found that in such boilers inter-crystalline cracks were developed in the steel by a combination of high static stress and corrosive action, although the number of cycles of stress was hardly high enough to cause a "fatigue" problem.

McAdam's tests have been very extensive and have shown very startling results due to corrosion acting simultaneously with repeated stress. Corrosion alone, or stress alone, is not nearly so disastrous as the two acting simultaneously. One of the striking features of his studies is that many of the fine heat-treated alloy steels are especially affected by corrosion-fatigue. Under the action of so mild a corrosive agent as a stream of fresh water, practically all the advantages of heat treatment and the alloying elements are gone.

F. N. Speller, National Tube Co., has experimented with chemical inhibitors of corrosion-fatigue with no small degree of success.

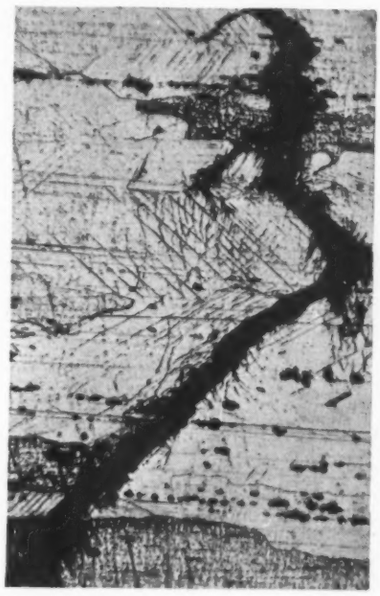

*Fig. 3 — The fine "slip lines" which mark the sliding of laminae within a crystalline grain of metal are shown, as is also a fatigue crack which, in general, runs parallel to the slip lines. In duralumin the fatigue crack becomes visible before the slip lines appear and hence the crack is much wider than the slip lines. In irons and steels slip lines usually appear before the fatigue crack is visible. Magnification 312 X. Micrograph by Prof. Tibor Ver, University of Budapest*

All these investigations have brought out the fact that the nature of the coating which is formed by corrosion, which always takes place, has a great deal to do with the damage caused. If the thin coating of oxide is hard and tough it acts as a protection against further corrosion. If it is loose, or if it becomes cracked, corrosion goes on at an accelerated rate at discontinuities in the coating. Protective coatings against corrosion-fatigue seem quite effective, but more experimentation should be done on this point. Even a heavy coating of grease seems to have considerable protective effect.

### Theory of Fatigue Failure Changes

The last few years have brought about a revolutionary change in our thinking in nearly all fields of physical science. In the field of the strength of materials, while the newer ideas have not been so dramatic as in some of the fields, yet they have involved profound changes

in thought. We do not at present know the nature of cohesion of the particles of a solid. We can go no further than to say that there seems to be something which acts like an "attraction," which tends to hold atoms together, probably balanced by a "repulsion" which keeps them a certain distance apart. Hence, atoms tend to form regular geometric patterns. Actually they gather in groups having different orientations of the ruling pattern. Probably, as a piece of metal solidifies, there is actually formed a network of minute cracks analogous to the cracks formed in the surface of dried mud. So that for a piece of metal only a small proportion of the cohesive actions of the particles of a solid is effective. These cracks do damage in two ways: (1) they actually reduce the effective area of cross-section of a piece of metal, and (2) there is a tendency for heavy stress-concentration at their ends. If this picture is true, it is not surprising that the tensile strength of a piece of steel is only about one-twentieth the theoretical cohesive value as determined by physicists. Under a steadily increasing load there comes a point where inside a crystalline grain, which may be thought of as a group of atoms all arranged in an oriented family pattern, a sliding occurs between layers of atoms. The result of this, as seen through the microscope is a series of slip lines or slip bands. This slipping does not imply fracture of the material; and after the slip, the material is actually stronger than before. The slipping does imply plastic distortion of the metal. Under this same load the little cracks which are supposed to exist in the material must spread somewhat, but after that spread there is a tendency for their ends to become more rounded and thus to reduce the stress concentration. Finally a position of equilibrium is reached in which the benefit of reduced stress concentration balances the damage of reduced area. Now if the load be repeated, and especially if it be reversed a great many times, there is a tendency for a grinding, and possibly a wrinkling action to take place along planes of slip and to start new cracks. At the end of the cracks already formed, as they open and close under repeated stress, there is a tendency for the stress-concentration to increase when they are sharpened by closing, and to become less when they are opened again. When, due to any action a crack spreads it probably is never "healed" by any action short of fusion. Hence the spread of a crack under repeated stress is a nonreversible cumulative process. It is, then, possible to have a progressive fracture, commonly known as a fatigue failure, under a repeated stress while the same stress applied but once would do no particular amount of structural damage to the metal.

This picture of fatigue failure is entirely different from the old idea of "crystallization" which was developed before the days of the metallurgical microscope. The tendency in steel under stress is not for a formation of a new crystalline system but for the fragmentation of crystalline grains already in existence.

## Data Important To Designers

*FATIGUE failure is of great importance to the designer. Probably there are many more fatigue failures of machine parts than failures by inelastic distortion. "Live" axles and shafts under bending loads constitute a common source of fatigue failure, and too much emphasis cannot be placed on the necessity for designing axles and shafts with large fillets and on seeing to it that they are machined with smooth junctions between fillets and straight portions. The machine designer cannot place too much emphasis on the necessity of using care in the location of keyways, holes, and screw threads.*—H. F. MOORE.

## Reviews Developments in Design of Metal Cutting Machinery

Speaking at the annual meeting of the Society of Industrial Engineers held recently in Cleveland, Richard H. Lansburgh, professor of industry, University of Pennsylvania, Philadelphia, emphasized the advances being made in the design of metal cutting machinery.

"Practically every machine tool on the market has been completely redesigned," said Professor Lansburgh. "Old-type tools such as engine lathes, radial drills, and milling machines have been made heavier, much more rigid, and the design changed providing for full automatic lubrication.

"Geared motor drives and antifriction bearings have enabled speeds and feeds to be increased tremendously without any further changes in fundamental lathe design. Changes in design of radial drills have likewise caused them to prove effective competitors of multiple spindle drills on work where the runs are not extremely long. The development of the hydraulic feed also is revolutionizing capacities of machine tools, old and new. This feed now is being utilized on 70 lines of machine tools. Similar advances have been made in milling machines, shapers, planers, and other standard types of machine tools.

# Reliability of Operation Increased By Use of Shielded Motors

CONVEYING systems are perhaps the most universal problem in industry today. No industry can function without recourse to some method of transportation either of raw materials or finished products from one place to another. Any interruption of such traffic is likely to tie up production with its consequent evils and losses. Nowadays when such a premium is placed on quantity production and continuity of such production, any act or failure that will in any way interfere with output is classed and rightly so, as a major sin to be guarded against with the utmost care.

Because conveying systems are so important it follows that the sources of power for such systems are of equal importance. This applies equally well to any conveyor whether it be an individual unit such as a motor truck or a continuous system of the belt or chain type, whether it handles materials in bulk or in crated parcels. Since such importance is attached to the continuous functioning of the conveyor, the driving motor should be selected carefully, and all factors which might influence the operation of this unit taken into consideration.

In the design of machines for specific conveying needs, load characteristics covering such items as starting and running torque, speed variations and horsepower characteristics, are normally accorded their due consideration. Items that are sometimes overlooked are the conditions under which the motors are compelled to operate and the steps which may be taken to guard against these conditions. Trouble may be expected ordinarily where motors are required to stand up under conditions of continuous operation, in rooms where the air contains dust in sufficient quantity to clog up the air passages in the standard open frame motors. When such clogging takes place, difficulties may arise due to overheating as well as the abrasive action and extra wear on both bearings and windings.

### Conditions Differ With Industries

Particularly is this noticeable in applications in metal working industries, factories, rock handling and crushing plants, wood working plants, cement mills, and such industries. Iron dust is particularly objectionable because it works into the windings and causes short circuits. This condition is encountered where iron dust is excessive as in steel mills, machine shops, grinding and finishing rooms, smelters and various other steel working plants. Where inflammable material is in suspen-

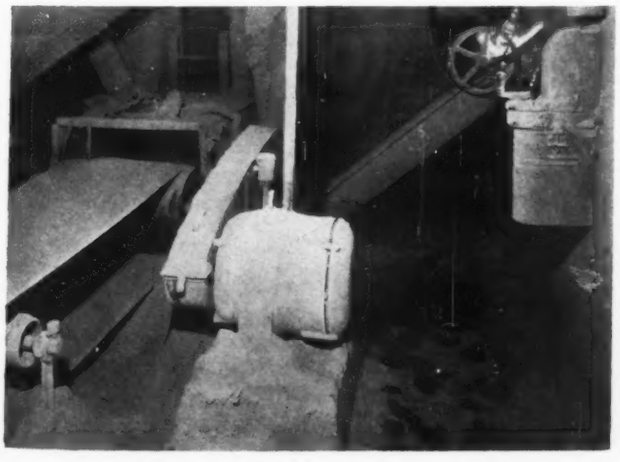

*Fig. 1—Motor driving belt conveyor in flour mill. Note heavy accumulation of dust as evidence of the conditions*

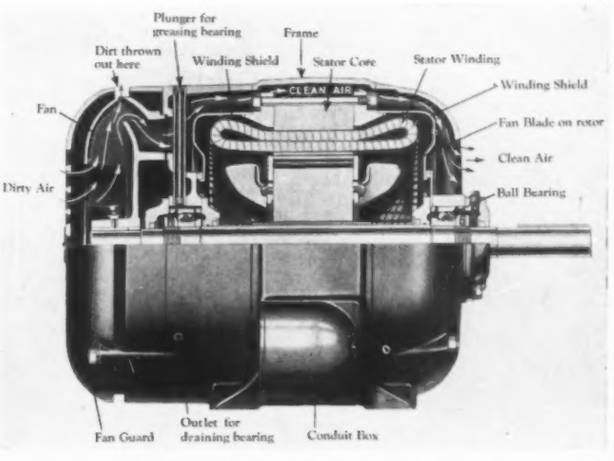


*Fig. 2—Cutaway view of motor showing totally enclosed stator windings and indicating the action of integral fan*

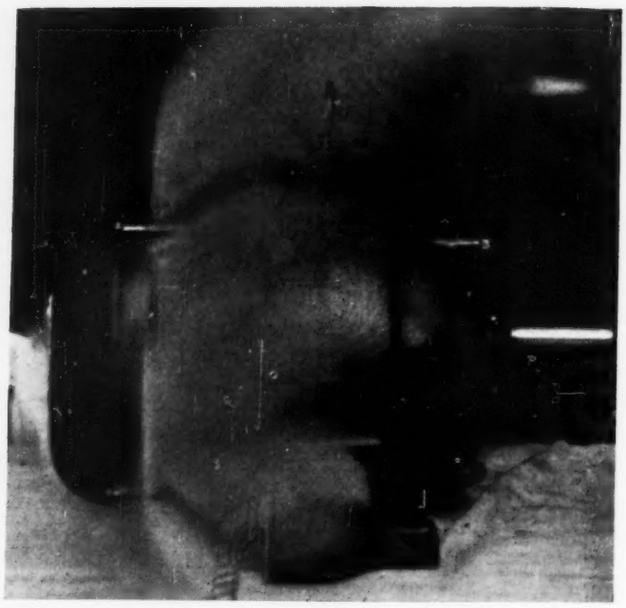

*Fig. 3—Graphic illustration of dust-removing properties of clean air jacketed motor*

sion in the air in considerable quantities, a spark is sometimes sufficient to ignite it and cause a serious explosion. Such materials as flour, feed, starch, fiber, wood, sugar, coke and coal dust in suspension are highly inflammable and should be kept from contact with motor windings.

Obviously in the interests of safety, continuity of operation, reduced maintenance charges and freedom from necessary attention, it is desirable to keep the windings of any motor from coming in contact with dirt particles suspended in the surrounding air. A number of motors have been placed on the market which accomplish this result among them being two types illustrated here which have been developed by the Fairbanks-Morse organization. In many cases where such dust conditions exist, the motor has been enclosed in a casing, with intake and exhaust ducts.

### Installation Sometimes Difficult

While it may be said that such a system is effective in accomplishing the desired result, it is sometimes objectionable for the reason that the necessary conduits are awkward to handle. They sometimes get in the way of belting and shafting and electrical conduits and furthermore being of rather light gage construction are damaged easily by being bumped. Where conditions permit, however, this makes an excellent installation and is very effective in keeping dust out of the motor. This point is illustrated in Fig. 4. Notice that the motor is located conveniently near a point of access to the outside air.

To retain the desired freedom from objectionable dust and at the same time to eliminate the disadvantageous features of extraneous ducts, a new type of motor is available which embodies in its construction an integral fan and dust eliminator. The construction is very compact and results have shown that it is effective in keeping the motor winding clear of all accumulations.

As shown in Fig. 2 cooling air is drawn through an inlet opening at the free end of the motor by means of a special built-in fan and is blown first across the winding shield at the free end and then through the annular space surrounding the stator core laminations thence across the winding shield at the pulley end and so out through the openings in the bearing arm. It will be noticed that the stator windings are completely enclosed by thin metal shields which prevent the cooling air from coming into direct contact with the windings themselves. Only clean air passes over the casing enclosing the windings.

### Dust Particles Are Ejected

The fan is so constructed with radial vanes and a suitable shrouding as to set up a considerable centrifugal action which is effective in throwing out all heavier-than-air particles through a narrow circumferential slot in the periphery. This action is well illustrated in Fig. 3 which shows an artificial test of the separator action. Freed of the suspended dust particles the air is deflected through an angle approximating 180 degrees and then passes into the annular cooling space.

Circulation of air around the coils themselves

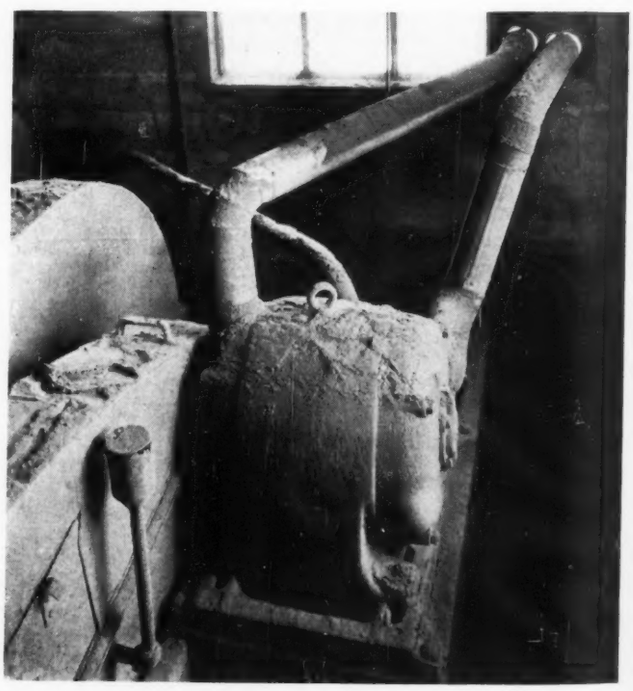

*Fig. 4—Enclosed ventilated motor operating flour mill conveyor. Heavy dust accumulations indicate severity of service*

is accomplished by means of the usual type of fan mounted directly on the rotor. While it is true that inasmuch as both the rotor and stator are completely enclosed and practically hermetically sealed, there is no through draft but the air contained in the space is kept in motion and serves to convey the heat generated in the stator coils to the thin metal casing where it is transferred to the outside cooling air.

### Dust Causes Wear in Bearings

It may be conceded that anti-friction bearings are effective in keeping any motor in the best possible operating condition and this is particularly true of a motor designed for operation in bad dust conditions. When dust of any nature, but particularly metallic dust, gets into the clearance space of a sleeve type bearing, excessive wear ensues and the result is that within a short time the air gap changes and it becomes necessary to replace the bearings. Such bearings, to produce the best results, should be oiled or inspected at least once every two weeks. Besides adding to the maintenance cost, this practice frequently results in the bearings either getting too much or too little oil. In one case the excess oil is spilled over the floor in the vicinity and quantities necessarily creep along the shaft and eventually find a way into the windings. Where an insufficient quantity is used, metal to metal contact in the bearing results and rapid wear takes place.

When anti-friction bearings are employed, as in the case under consideration, grease is used as a lubricant and enough is supplied to last for usually a year at a time without attention. This grease, if it is of the proper grade, does not escape along the shaft nor does it permit dust to work in. The result is long life, minimum friction losses, uniform air gap, freedom from attention and generally satisfactory service.

Fig. 4 shows a motor of this type installed in a flour mill at Omaha, and serves to illustrate the severe dust conditions in which they often operate. This particular unit is driving a belt conveyor through the medium of a chain drive which also is enclosed for protection against the arduous conditions.

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## Next Machine Tool Show in 1932

Following a discussion of the date of the next machine tool show, members of the National Machine Tool Builders' association in convention at Briarcliff Manor, N. Y. voted 39 to 28 to hold the event in Cleveland in 1932, the exact time to be decided later.

# How Field Facts Help Sales and Design

(*Concluded from Page* 25)

In addition, O. D. Reich, Dexter Folder's works manager, reports as follows:

"Whenever we contemplate the redesign of one of our machines or the design of an entirely new machine, we send out a questionnaire to all those in our organization whom we consider qualified to make suggestions which may be of help in making the proposed product as well designed from all standpoints as it is possible to make it. These questionnaires go to the salesmen, to various erectors, the service men and to the members of our own engineering force. When the replies are received, they are tabulated for the benefit of the head of the engineering department and designer.

"Another source of valuable information for our engineering department is the close follow-up of all complaints. Every letter of complaint, whether from a customer or a member of our own organization, is given the most careful attention and is followed through in a thorough and painstaking manner. These complaints are tabulated and used as a guide for our engineers and for the inspectors in the shop.

"Another source of information is our sales engineers. We have several men who have been brought up in our engineering department, but who have specialized in visiting outside plants and in adopting our machinery to their requirements. These men are an invaluable source of suggestions for improvements in our product, and after each visit to the outside they turn in a complete report which is very carefully gone over by the chief engineer and all other members of the engineering department who may be concerned."

In this system there are two points well worth the attention of other designers of machinery.

### Complaints Are Not Awaited

Notice, first, that there is no waiting for complaints; no assumption that unless a complaint comes in "everything is jake." The search for possible improvements suggested by the customer's actual use of a machine begins before ever there has been opportunity for a complaint. The substance of this lies in questions six and seven on the erector's report: "Have you any suggestions to make regarding machine?" and "Have you any suggestion to make regarding equipment for this style of press? Make sketches if possible on reverse side of sheet."

As the second point, notice the pains that are taken to see that out of each complaint will come a permanent improvement, if "trouble" is in any way the fault of the machine itself. This is evident in both the first and second paragraphs of Mr. Vogt's outline.

*In the next issue, Mr. Hoskins relates how upwards of a dozen manufacturing companies use customer contact to best advantage.*

# MACHINE DESIGN

# Broaden Your Perspective!

*Editorial*

A FEW weeks after the armistice was signed, it fell to the lot of several companies of American soldiers to be quartered in a small town on the Moselle river in Germany. It was a small village, with 800 inhabitants, practically all of whom sprang from common stock. Old residents declared that several generations had passed without a new family coming into the community from outside. The burgomaster complained that the town needed new blood. It was sorely deficient in the enthusiasm, energy and initiative that is derived from the injection of the outside viewpoint. The village folk were suffering from introspection.

SOMETIMES one wonders if a like situation does not exist among design engineers in certain industries. Is it not possible that the absence of initiative and the paucity of ideas reflected in the design of mechanical equipment in a number of branches of manufacture are due to the narrow perspective of the designers? And conversely, isn't it true that the engineers who are most successful are those who are constantly looking for ideas beyond the confines of their own preserves?

WE NEED not go beyond the pages of this issue to find evidence of dramatic achievements attributable to broad perspectives. The engineers and contractors who developed the mechanism which swings the 600-ton doors of the Goodyear-Zeppelin airship docks as easily as you open a cupboard door derived their ideas from years of experience in designing and building ore bridges and unloaders. Those responsible for introducing herringbone gears in an automobile transmission obtained their hint from heavy gear reduction practice. The suggestion for simplifying the control of a street car so that the motorman can drive it like an automobile came largely from the automotive industry, although there are evidences that experience in the oil-electric traction car also figured in the development. The increased favor with which light alloys is being received in the manufacture of automobile engines is due to pioneering of airplane engine designers.

AND so it goes. One could cite dozens of important instances whereby a new material, method or part introduced in one industry, soon finds application in others. This free interchange of ideas is an accepted dominant characteristic of American engineering practice. To ignore its existence or to shut one's eyes to its possibilities spells disaster in these days of rapid-fire development.

WE CANNOT over-emphasize the desirability of looking to outside sources for suggestions. If, for instance, you are struggling with a problem in connection with the folding of sheets and pillow-cases on laundry machinery, do not confine your studies to what your competitors in the laundry machine field have done. Strike out into other fields. Find out how other materials are folded. Watch the operation of a paper folder on a printing press; possibily you will see something that with proper modifications may be adapted to your problem of folding cotton.

REGARDLESS of what line of design you are in, look beyond your field, and you will be rewarded handsomely. Broaden your perspective!

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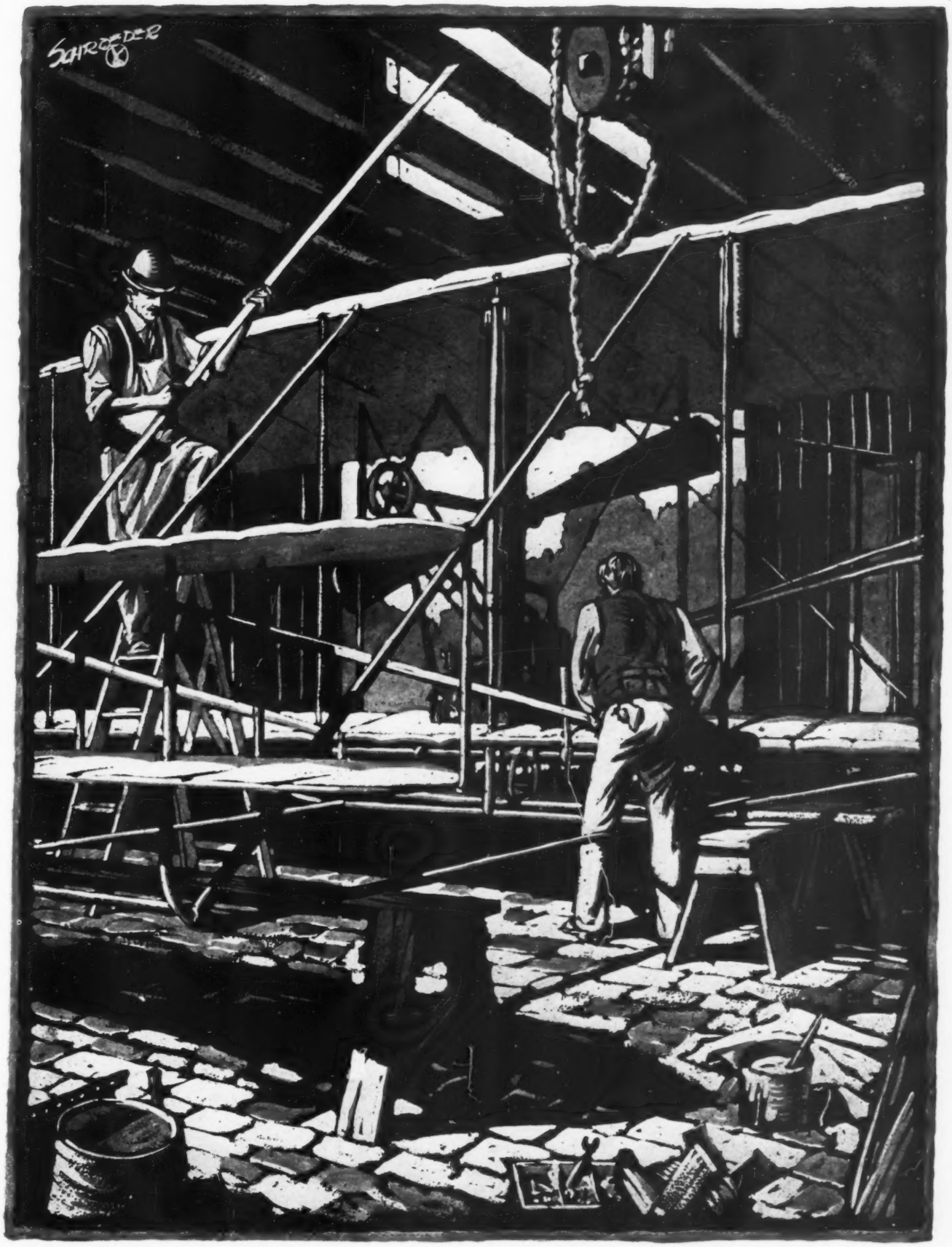
## Keep Posted on Fatigue

AS TOLD elsewhere in this issue by Prof. H. F. Moore, pioneer in seeking the facts regarding fatigue, the efforts of this research is beginning to bear fruit. The stress-cycle diagrams have proved useful, the dangers lurking in sharp fillets and threads in shafts are more generally recognized, and new light recently thrown on the theory of the structure of metals seems significant.

THESE developments are of extreme importance in machine design. They will prove even more so as the demands of lighter and swifter airplanes bear more heavily on designers. We recommend Professor Moore's discussion to every engineer who deals with design of parts subjected to reversed stresses.




Wright Brothers and Their Airplane

*Great Moments in Machine Design—Third of a series of original drawings prepared exclusively for this magazine symbolizing the designer's contributions to the progress of mankind*

# Scanning the Field for Ideas

*A Monthly Review of New Machinery, Metals and Parts, with Special Attention to Significant Design Features and Trends*

***Light Alloys Gain Favor—New Control for Street Cars—Herringbone Gears in Automobile Transmission—More Antifriction Bearings in Steering Mechanisms—Turbulent Heads for Motors***

IN CONSIDERING the free dissemination of ideas throughout industry, which now is a distinct characteristic of American design practice, one's mind instinctively turns to the many contributions to other industries that may be credited to the automobile. As yet, we have not thought of motor car design as having been the recipient of ideas from other lines of manufacture.

However, no less an authority than Charles F. Kettering, president of the General Motors Research Corp., is responsible for the statement that the automobile industry is receiving benefits from developments traced directly to aeronautical practice.

"Lightness of construction (of motor cars)," he declares, "is something we learned from airplane construction. Aluminum, lynite and invar all came into automobile construction by way of the airplane."

Mr. Kettering believes that the automobile of the future will make the present-day contraption "look like a hay wagon" and that within 10 years we will have automobiles safely traveling 100 miles an hour, weighing less than 1000 pounds, costing less than $1000 and covering 80 miles on

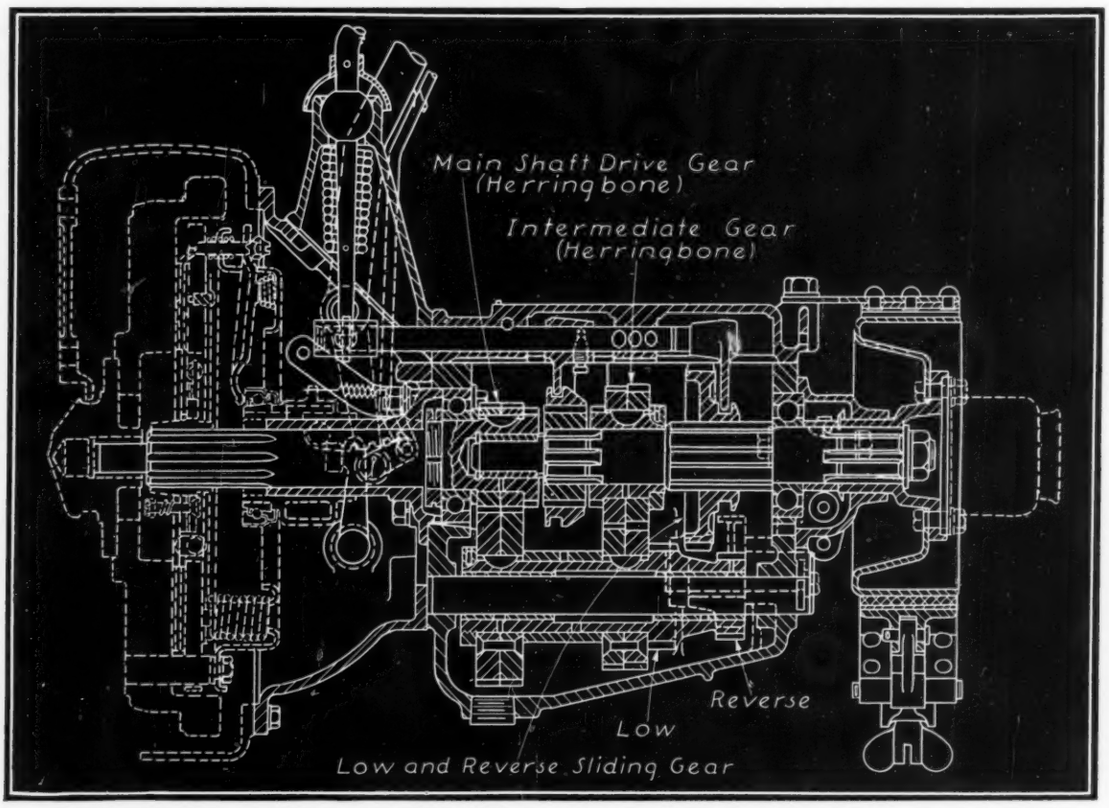



*Fig. 1—Sectional view of transmission, showing gears and sliding dog clutch*

*Fig. 2—Control seat of experimental street car. Brakes and controller are foot-operated*

a gallon of gas. Apparently hope for these accomplishments is predicted on the perfection and use of lighter materials of construction.

In view of this prediction, the progress being made in the development of light alloys is significant. One of the new materials which shows distinct possibilities is high magnesium alloy, a typical example of which contains 92.6 per cent magnesium, 7.0 per cent aluminum and 0.4 per cent manganese. The material is only about two-thirds as heavy as aluminum, having a specific gravity of approximately 1.75. It is employed to a certain extent for forged propellors, cast pistons and structural shapes. Dr. W. G. Harvey, of the Aluminum Co. of America, made the statement recently that production of magnesium castings has increased two hundred times in three years. He claims also that, though magnesium alloy has certain disadvantages, its strength-weight ratio, in sand cast condition, is higher by about 50 per cent than good casting alloys high in aluminum.

### Another High Strength Alloy

Another material about which comparatively little is known and which is so new that it still is in the experimental stage, is beryllium. According to Dr. Gillett, director of the Batelle Memorial institute, this material has the same specific gravity as magnesium, the modulus of elasticity of steel and, for an alloy with a small proportion of aluminum, a strength in excess of any other light alloy. He gives the strength of a 70 per cent beryllium and 30 per cent aluminum alloy as 70,000 to 100,000 pounds per square inch. The high modulus of elasticity of beryllium-aluminum alloy should make it suitable for springs, propellor blades and other parts particularly subject to vibration, and its low thermal expansion renders it a distinct possibility as a material for pistons of aircraft engines, where weight also is a factor. But there are disadvantages connected with this material, chief among which are its scarcity and relatively enormous cost; also it is so brittle as to make doubtful the possibility of cold rolling or cold working it.

### Street Car Is Controlled By Feet

AN EXPERIMENT that suggests innumerable applications in many lines of manufacturing activity is being conducted in Albany, N. Y., where a street car equipped with control similar to that of an automobile is being operated. The car has been equipped electrically by the General Electric Co. with special attention to more rapid acceleration, increased braking and speedier loading. The motorman, instead of standing, swinging a controller handle and stamping on the gong, sits in a comfortable seat, Fig. 2, and controls the car by movements of the feet. His hands are free to manipulate the door mechanism and to make change for passengers. The convenient arrangement of controls is shown in Fig. 3.

When driving, the motorman applies power by pressing the ball of his left foot on a controller or accelerator. Under normal conditions he brakes the car with the right foot, but in emergencies stops it by raising the heel of his left foot which has been resting on an emergency brake heel-plate. This plate is shown at the left of Fig. 3, and the other brakes, of which there are four, also are indicated. On hand-operated cars there are usually only three brakes, the extra one in the car under discussion clamping down on the rails between the trucks and adding a valuable safety factor for heavy traffic conditions. The other brakes are the regular air-operated, the

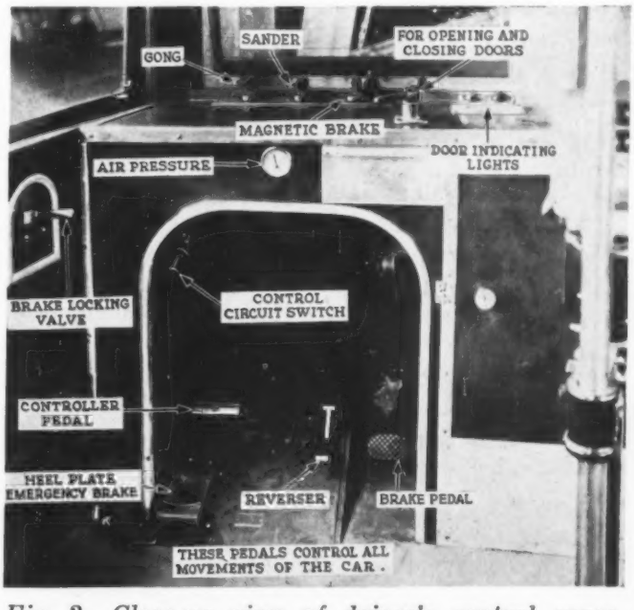



*Fig. 3—Close-up view of driver's control space, with seat removed*

emergency dynamic and a hand-operated brake.

With this new type of car, tests show that a decrease of from 15 to 20 per cent can be effected in running time. Most of this saving undoubtedly can be laid to the improved system of control. But it should be taken into account that it is due to the operator being seated that full advantage can be taken of the improved methods.

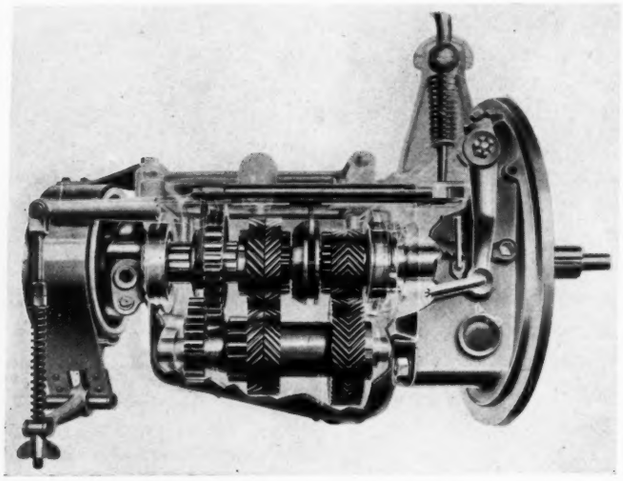


*Fig. 4—Cutaway view of transmission, in which the different tooth pitches of gears may be seen*

The question arises immediately: "If this arrangement is desirable for a street car motorman, why shouldn't it be desirable for crane operators, locomotive engine men, and others whose technic would be improved by more sensitive control?" This is an idea for designers to probe.

### Spur Gears Are Discarded

HERRINGBONE gears for automobiles! For some years we have observed the increasing employment of herringbone gears for transmission of power in industrial applications and for the replacement of spur gears where quietness and smoothness of operation are essential. We have also seen the use of the helical or spiral gear—which can be compared to the right or left hand half of a herringbone gear—for some automobile front-end drives. But the double-helical, or herringbone gear, has not been used extensively in automotive practice. Now, however, at least one automobile company is adopting this type of gear. It is to be used in the gearbox of the Master Flying Cloud, built by the Reo Motor Car Co., for both the constant mesh and the second speed gears.

Redesign of the gearbox has been necessary, since the engagement of the gearing by sliding action obviously is impracticable. The new design is shown in Fig. 1. From this it can be seen that the herringbone gearing is engaged by means of a dog clutch which is splined to the main shaft. The second gear on the main shaft is free to revolve except when the internal teeth of the dog clutch engage external teeth on the second gear and lock it to the shaft. For "high," the dog clutch engages the end of the engine clutch shaft in the usual manner and low and reverse gears follow closely the usual style.

### Tooth Pitches Are Varied

An unusual feature of the herringbone gearing is that the right and left hand sections of the gears for second speed have different tooth pitches, as may be seen from Fig. 4, and each of these tooth pitches is different from the pitch of teeth on the constant mesh gear. It is said that the effect of the three varying pitches reduces sound vibrations to a minimum. To maintain the quiet running adjustment is provided for the two halves of the gear on mainshaft, and for the two halves of the driven countershaft gear; screw collars are utilized for obtaining these adjustments.

The adoption of herringbone gears for this application undoubtedly will effect a reduction in driving strain, particularly in heavy traffic, by reducing noise and vibration; also by eliminating the possibility of clashing gears between second and high. It is claimed that the gear change from second to high can be made at any car speed, or down from high to second at speeds up to 40 miles per hour.

Another development in the automotive field is in connection with steering. The Ross "roller mounted" steering gear will, it is claimed, increase ease of steering by 23 to 40 per cent as compared with the easiest steering previously developed. This is made possible by a reduction in

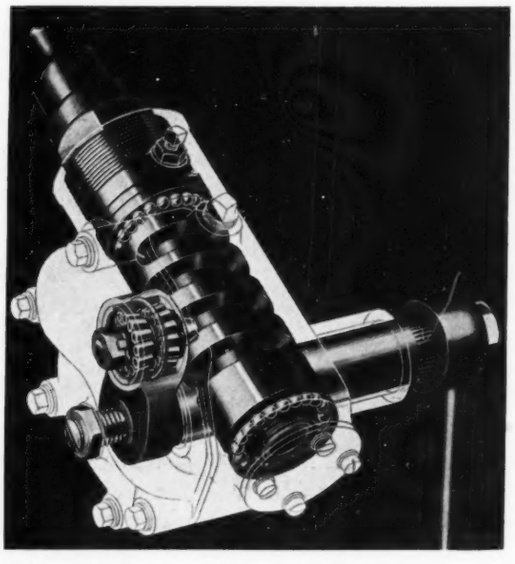


*Fig. 5—Ross roller mounted gear, in which cam and lever are used*

friction between the spiral cam and lever of this type of gear. A tapered roller bearing is mounted on the lever stud through which the steering effort is transmitted from the cam to the lever. Rolling action thus is obtained between the stud and cam in place of the former sliding contact. Steering gear efficiencies are supposed not to exceed 54 per cent while the new Ross gear shows from 64 to 79 per cent.

### Design Features of New Car

ONE of the latest cars, the Rolls-Royce Phantom II, while not revolutionary, embodies many features of special interest to designers and worthy of note in the engineering field in general. The engine has a new cylinder head in which the combustion chambers are so designed as to provide, in conjunction with the location of the valves, a pronounced turbulence; this, it is said, provides about 15 per cent more engine power with the same bore and stroke as formerly. There are two sets of spark plugs—one for battery and the other for magneto ignition. Each set of plugs is located on opposite sides of the engine, and synchronized timing is effected by means of a hydraulic governor which is connected to the contact breakers of the two systems. The throttle also is controlled by a governor although this is augmented by regulation by hand up to a point and by the accelerator pedal throughout the full range.

For starting the car an entirely separate carburetor is furnished and a control on the dashboard enables the driver to switch over at will to the main carburetor employed for running positions. A further control is provided for regulating the mixture, if essential, for extreme atmospheric or driving conditions. Atmospheric conditions also are taken care of by utilizing water heating for the induction tracts instead of the usual exhaust heating; it is claimed for this that some of the variations arising from extreme temperatures are eliminated.

### Hypoid and Ground Spur Gearing Used

Two points of note regarding the gearing employed in this car are, first, the use of ground gears for the constant mesh and indirect ratios, and second, the incorporation, in the rear axle drive, of hypoid gearing.

For chassis lubrication a three-point system is employed. This enables the whole of the chassis with the exception of the propellor shaft universal joints to be lubricated by a pedal which passes through the dashboard to an oil tank under the hood, and by two grease nipples on the front and rear axles. The springs are included in the many parts lubricated by the pedal oil feed. The employment of such systems of lubrication is spreading, and is more than welcome to automobile operators; they are a valuable asset to cars, just as is centralized lubrication to machine tools. Does the advance in lubrication methods mean that in the future there will be a centralized system for all good grade cars, or that the chassis eventually will be oiled automatically by a pressure system operated by an engine-driven pump?

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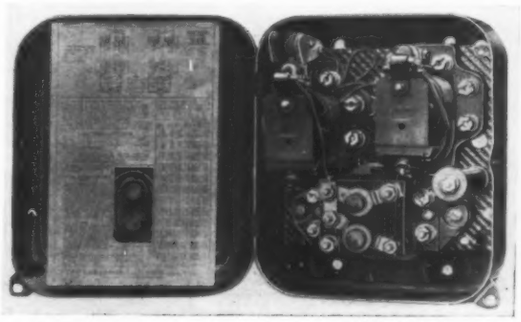
## Across-the-Line Starter Designed for Direct-Current Motors

Interest in the development of linestart electric motors to meet new requirements in industry has stimulated the design of a number of new type starters. Into this field Cutler-Hammer Inc., 161 Twelfth street, Milwaukee, has introduced a new automatic, across-the-line starter



*View showing details of across-the-line starter*

for direct-current motors up to 2 horsepower, 115 or 230 volts.

Included among the features incorporated in the design of this new unit are a small size, double line break, thermal overload protection, low voltage protection, silver contacts and completely enclosed structure, as shown in the accompanying illustration. Two magnetic contactors, one in each side of the line, connect the motor directly across the line on starting and provide a double line break.

The contactors are designed especially for direct-current service and have renewable contacts and a heavy stamped frame. Thermal overload relays are of the fusible alloy type and can be adapted to any size motor by changing heater coils. The relays are reset by pushing a button in the cover when they are tripped by an overload. Starters are furnished with a pushbutton master switch providing three wire control.

Master switch can be provided mounted in the cover of the starter or can be arranged for mounting separately. The starters are made also without the thermal overload relays for applications where protection of this nature is unnecessary.

# MEN OF MACHINES

*Personal Glimpses of Engineers, Designers, and Others Whose Activities Influence Design*

THOMAS J. LITLE JR., for three years chief engineer of the Marmon Motor Car Co., Indianapolis, has announced his resignation to enter the professional field as engineering counsel and industrialist. He formerly was closely associated with Henry Ford and has been engineering executive of the Lincoln and Marmon companies, vice president of the Copeland Electric Refrigerator Co., and president of the Society of Automotive Engineers. Mr. Litle is considered an international engineering authority, and has as many as 225 inventions to his credit. In his consulting practice he will maintain offices at Detroit and Indianapolis.

* * *

TO HENRY BUKER, president for the past year of the National Machine Tool Builders' association, must be credited to a large extent the signal success of that association's recent exhibition and congress held at Cleveland. Mr. Buker has been connected closely with the machine tool industry for about 37 years, having been with the Brown & Sharpe Mfg. Co., Providence, R. I., during that entire period. He had an engineering training before joining the company but elected to take its apprenticeship course as a basis for his later activities. Later he was made an assistant foreman and held various positions until he became vice president and general sales manager in 1924. He is a member of the American Society of Mechanical Engineers, the Engineers Club of New York, and numerous other national and local organizations.

* * *

FRANK O. CLEMENTS, technical director of the General Motors Corp. Research laboratories, Detroit, recently was elected vice president of the American Society for Testing Materials. Mr. Clements has been identified with research engineering for many years and joined the General Motors staff in 1920 as technical director of the research laboratories at Dayton, O. In 1926 he transferred to Detroit to take up duties of the position he now holds. He had been an active participant in the work of the Society of Automotive Engineers, having served on various committees of that society. He also is a member of the American Chemical society, the American Electrochemical society, the Institute of Metals (British), the American Association for the Advancement of Science and other engineering organizations.

* * *

JOSEPH B. DEISHER, author of an article appearing in this issue on the subject of malleable cast iron, recently became works manager for the Columbia Malleable Castings Corp., Columbia, Pa. As may be noted from a brief sketch which appears in the body of his article, Mr. Deisher has been connected closely with the malleable iron industry for many years, latterly as shop practice engineer for the Malleable Iron Research institute. His numerous other business activities are outlined in the sketch mentioned above.

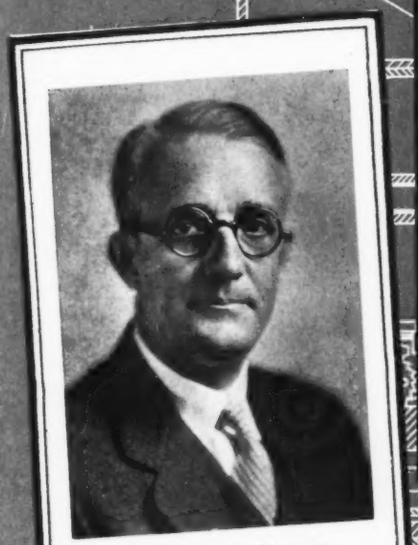
* * *

R C. ROLFING recently was elected vice president and general manager of the newly merged Oliver Farm Equipment Co., Chicago. In this merger were included four companies who were considered to be among the leaders in the agricultural machinery industry, namely, Hart-Parr Co., Nichols & Shepard Co., Oliver Chilled Plow Works, and the American Seeding Machines Co. Since the formation of the new company about a year ago, the McKenzie Mfg. Co., also has been added to the major organization. Mr. Rolfing originally was connected with the Hart-Parr Co., latterly as vice president and works manager, and contributed substantially to improvement in design of the former Hart-Parr tractor. He also has proved extremely efficient in production methods and plant management. Other officers of the new company are James D. Oliver, chairman of the board, M. W. Ellis, president; W. A. Weed, vice president; W. D. Fowler, treasurer; and D. A. Freeman, secretary.

* * *

RECENT changes in the organization of the White Motor Car Co., Cleveland, following the death of its president, Walter C. White, included the election of H. D. Church to the office

# Leaders in Design, Engineering and Research



THOMAS J. LITLE

HENRY BUKER

F. O. CLEMENTS

J. B. DEISHER

R. C. ROLFING

H. D. CHURCH

of vice president in charge of engineering. Mr. Church has been director of engineering since May, 1925, when he joined the White organization. His engineering record in the automotive industry reaches back a number of years and includes such companies as the Packard Motor Car Co. in which he served as chief engineer of the truck department 18 months before becoming associated with the White organization. He formerly was also assistant chief engineer for the Chevrolet Motor Co., Detroit, and before that was assistant to the chief engineer and later consulting engineer of the Hare Motor Co. for two years.

* * *

Erwin J. Mohr has been appointed manager of industrial sales of the Gunite Corp., Rockford, Ill. Mr. Mohr is widely known in the field, having served many years as sales manager for the Kinite Corp., Milwaukee.

* * *

G. H. Hedrick has been appointed chief engineer of the Gem Mfg. Co., Pittsburgh, maker of railroad equipment, stampings and flexible shafting. Mr. Hedrick was formerly vice president of the Thomas Spacing Machine Co., Pittsburgh.

* * *

Alexander Saharoff recently was appointed general superintendent of the Cincinnati works of the Worthington Pump & Machinery Corp. Mr. Saharoff has been with the Worthington Corp. since 1915. Prior to his recent promotion he was head of the experimental department.

* * *

Walter Knapp has been appointed executive engineer of the DeWalt Products Corp., Leola, Pa., manufacturer of high-speed cutting equipment for wood, metal and stone. Mr. Knapp was graduated from Cornell university with a degree in mechanical engineering and his experience extends into the fields of research engineering and design development.

* * *

Joseph C. Rah has been appointed consultant with the Delta-Star Electric Co., Chicago. He was formerly with the G. & W. Electric Specialty Co., Chicago, in its engineering department.

* * *

George W. Gunner has been appointed chief designer of the Sikorsky Aircraft Corp., College Point, Long Island, N. Y.

* * *

B. L. Conley has severed his connection with the Holtzer-Cabot Electric Co., Boston, and has been appointed chief engineer with the Sunlight Electrical Mfg. Co., Warren, O.

* * *

Harold O. Malcom, formerly with the Parks Aircraft Co., St. Louis, has been appointed chief draftsman of the Spartan Aircraft Co.

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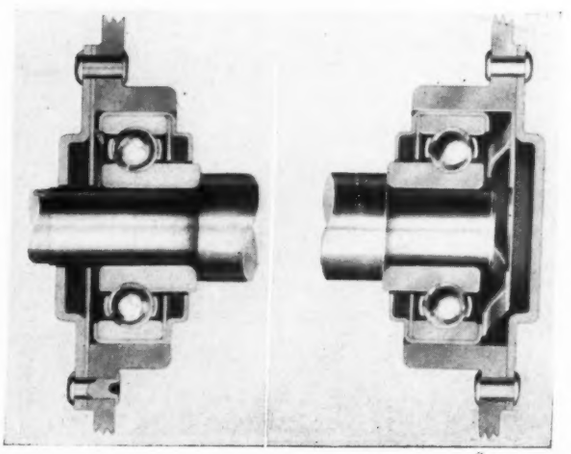
## Newly Designed Ball Bearing Has Self-Sealing Features

Of interest to designing engineers is the self-sealed and self-lubricated bearing recently announced by the New Departure Mfg. Co., Bristol, Conn. Manufactured only in smaller sizes, the newly designed bearing consists of what is essentially a single-row ball bearing of the non-loading groove type, permanently fitted into a metal case or shell.



*Two adaptations of the self-sealed, self-lubricated ball bearing*

One side of the shell is shaped so as to contain a felt closure which fits over the outside diameter of the extended bearing inner ring, forming a seal for the retention of lubricant and exclusion of dirt. Although the inner ring is carried slightly beyond the face of the seal in order to facilitate removal of the bearing without damage and to prevent interference between the shaft shoulder and the seal, the overall width of the seal bearing is less than the space occupied by a standard bearing with a separate closure member.

Outside bores and diameters are standard. Capacity characteristics of the new bearing are substantially the same as corresponding sizes of non-loading groove single-row bearings. Sectional views of two different applications of the seal bearing are shown in the accompanying illustration.

# The Editor's Mail Basket

*LETTERS and telegrams voicing the approval of readers of Machine Design continue in a steady flow to the editor's desk. They bear witness of the welcome with which this new publication has been received. Moreover, the congratulatory and complimentary messages are evidence that the journal is meeting a need long felt by those interested in the field of machine design. The ultimate conclusion to be drawn centers on the fact that the broad scope of the editorial content is claiming the attention and study of constructive minds. Expressions of interest come from large manufacturing concerns, executives, chief engineers, college professors and hundreds of others connected in one way or another with the design profession. Sales departments, with which design is coming to be more closely related, see the importance of a journal of this type and consequently have joined in the reception. One large company is asking for some of the art work to use in its house organ. It telegraphs:*

"May we use picture of Archimedes' Pump, October number *Machine Design*, as illustration, provided credit is given?"

*The following letter received from the vice president of a large manufacturing company typifies the executive's opinion of what Machine Design is accomplishing in its field:*

"Enclosed please find my check covering two years' subscription.

"May I add my hearty congratulations to the healthy idea which prompted you to start *Machine Design*.

"In my twenty years' experience of automatic machinery engineering and design, this is the first publication which tackles this problem in the right light, proper background and essential dignity.

"Indeed, the paper fills a long felt want and I sincerely trust that you will receive a very well deserved support necessary to successfully continue the good work."

*Here is what another chief draftsman says:*

"If comparisons are permitted, I believe your second issue even more attractive than the first, and you know I liked that immensely. Your editorial 'Consult the Parts Maker' not only tells something that needs emphatic telling, but also tells it remarkably well. Congratulations."

*Chief engineers are enthusiastic about Machine Design. Their own testimonials are convincing proof:*

"The copy you sent me of *Machine Design* is the second one I received, and I thought this publication was a very good one.

"If this magazine continues to give as much interesting data as contained in the early issues, I am sure that it will be a big success in the field."

"We have been quite pleased, especially with the second number of *Machine Design*, and wish you well on your new venture.

"In some communication you asked for suggestions, so we are taking the liberty of making one, and that is, that if convenient, you follow the policy of the A. S. M. E. and use 8½ by 11-inch paper, and punch it as the A. S. M. E. papers are published. This greatly facilitates filing, and is also a very great help in case the magazine is taken apart and articles rearranged under other headings."

*An assistant chief engineer of a well-known company expresses himself as follows:*

"We have noted with interest your two issues of *Machine Design* and believe that this magazine should prove of exceptional value."

*The reaction among professors in colleges and universities throughout the country is particularly gratifying. Their knowledge of the design field renders them highly competent to offer criticism. The following statements come from three of them:*

"The October number of *Machine Design* came to my hands recently, and I wish to compliment you on the splendid appearance of your magazine."

" . . . and be pleased to see an article concerning it published in your greatly welcomed *Machine Design*."

"As I think this journal is worthy for which to be subscribed, I think it worthy of being bound."

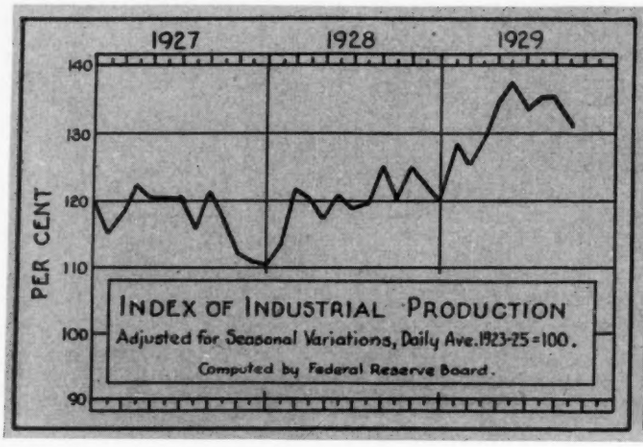
*Another letter is indicative of the service Machine Design is performing. This letter follows:*

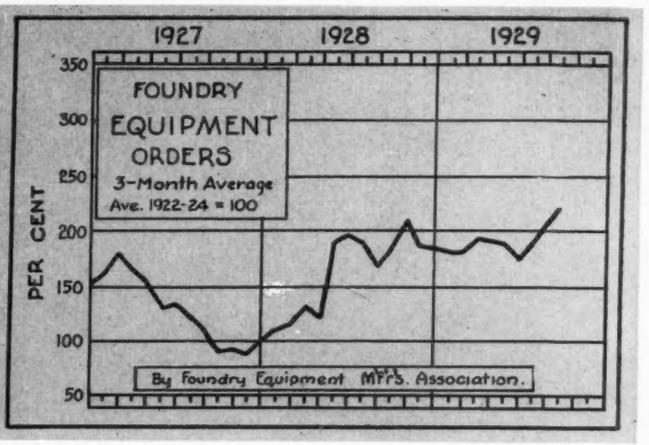
"I was particularly interested in the article on antifriction bearings, which appeared in the second issue, as it contains much information of value to the machine designer."

*Engineering departments are finding Machine Design of great assistance in planning their organizations. In the following letter from a prominent machine company reference is made to the value of a current series of articles on organization and supervision of the design department:*

"The series of articles appearing in your publication, entitled 'Organization and Supervision of Design Department' is very interesting to me, as we are at the moment rearranging the methods of our engineering department and we are desirous of having up-to-date information on engineering office methods and forms.

"Would it be possible to get copies of the balance of the unpublished series at this time so we could review them?"



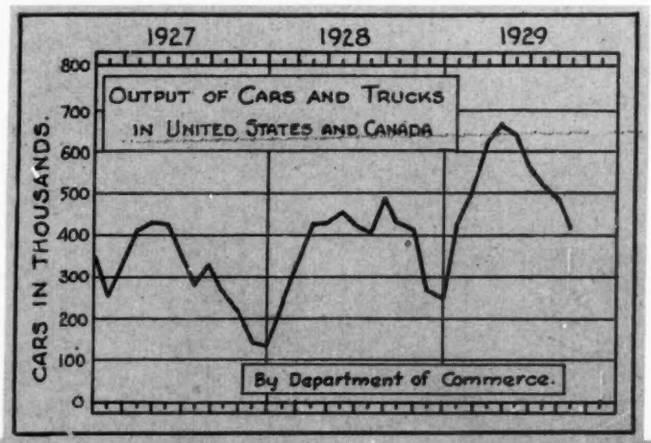



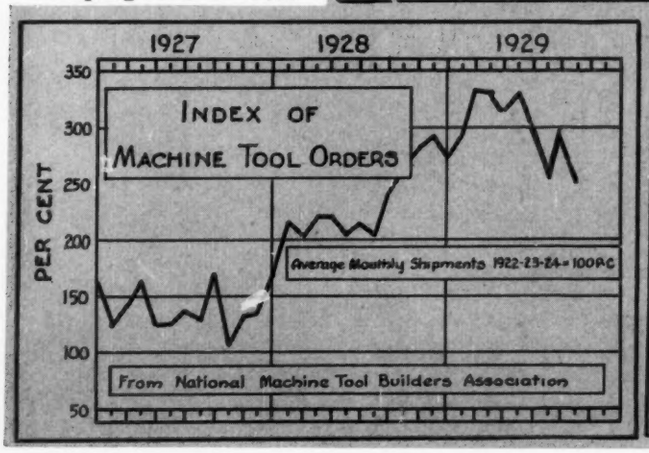

# How Is Business?

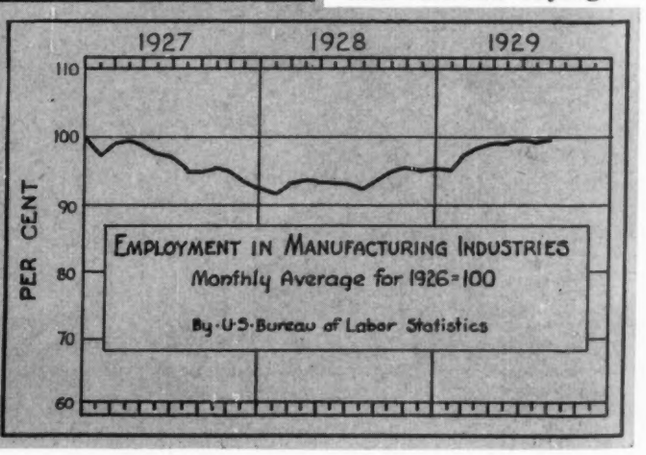
GENERAL industrial activities during recent weeks have continued somewhat further the slackening tendency noted in this review one month ago. The decline in the automobile industry, following a period of unprecedented activity, has been most pronounced. This has been reflected in reduced iron and steel demand from motor car companies, although requirements from the steel mills for the railroads and various miscellaneous users continue good.

An event which has overshadowed all others recently has been the extensive and volent decline in stock market quotations. This has had something of an adverse effect upon business and financial psychology, but is has brought no fundamental change in the outlook. There has been no wiping out of real wealth in the country, merely a writing down of fictitious share values. Large numbers were in the stock market, but their proportion of the whole population was small, probably 4 per cent.

Over against the unfavorable effect of the stock market decline on business through its effect upon sentiment and upon purchasing power, are important benefits flowing from the checking of extravagant speculation. Chief of these has been the correction of the credit situation. Tight money in this country as well as in Europe was attributed to Wall street conditions. The downward revision of values cut down brokers' loans by about $2,500,000,000 in October and bank rates have been lowered here and in England. Easier money rates should have a stimulating effect upon building and railroad buying.



# NOTEWORTHY PATENTS

*A Monthly Digest of Recently Patented Machines, Parts and Materials Pertaining To Design*

STUDY of the constant-clearance valve mechanism for which the United States patent office granted Andrew V. D. Willgoos, West Hartford, Conn., patent No. 1,729,849, reveals a number of features of interest to the designer. Mr. Willgoos, the inventor, has assigned his patent to the Pratt & Whitney Aircraft Co., Hartford, Conn.

In general the invention pertains to internal combustion engines and more particularly to means for maintaining constant valve clearance to prevent differential expansion due to variance in degrees of temperature attained by parts of the valve-actuating mechanism and other parts of the engine. Because the push-rods for operating the valve mechanism in the conventional aircooled motor usually are exposed to the cooling air, they fail to attain the high temperature reached by the cylinder proper. Consequently these parts differ in amount of expansion, causing a considerable variance in the clearance of the valve thus affecting the performance of the engine.

The object of the invention is to provide a valve actuating train including means for compensating for this difference in expansion and thus to insure a constant valve clearance.

Fig. 1 of the accompanying illustrations is a central vertical section through a portion of an aircooled engine embodying the invention. Figs. 2 and 3 are details, partly in section, showing a modification of the push-rod housing joint and push-rod train.

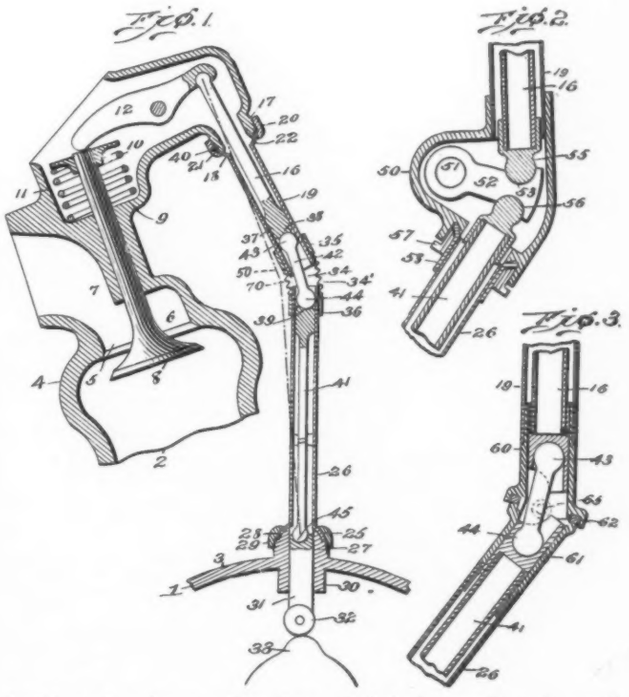
A description of the mechanism shown in Fig. 1, for operating each valve follows: An extension 11 of the upper end of the boss 7 is formed to provide a seat 9 for the valve spring 10, and a housing and mount for the rocker arm 12. The extension 11 has a bore for receiving one of the push-rod members 16 and has an externally screw-threaded projection 17 surrounding the bore. The end of the extension is rounded off at 18 below its screw-threads, to form a smooth fit with the arcuate upper end 22 of the push-rod housing 19.

A suitable gland 20 having a suitable face 21 curved to correspond to the curvature of the housing end 22, is adapted to be screwed onto the extension 17 to hold the push-rod housing in place though permitting a very limited oscillatory movement on the rounded extension end 18. Suitable resilient packing 40 may be provided to prevent escape of oil from the housing.

The crankcase 3 has a somewhat similar structure for holding the lower end 25 of the push-rod housing 26. Housing portions 19 and 26 are hinged at 34 and a resiliently flexible member 34, secured to the housing portion collars 35 and 36, is employed to prevent escape of oil and ingress of dirt.

The lower end 37 of the push-rod member 16 is provided with a socket 38, while a similar socket 39 is provided in the upper end push-rod member 41. A link 42 terminating in ball-shaped end 43 and 44 fitting in sockets 38 and 39, is provided between the push-rod members 16 and 41.

When the engine is in operation the tempera-



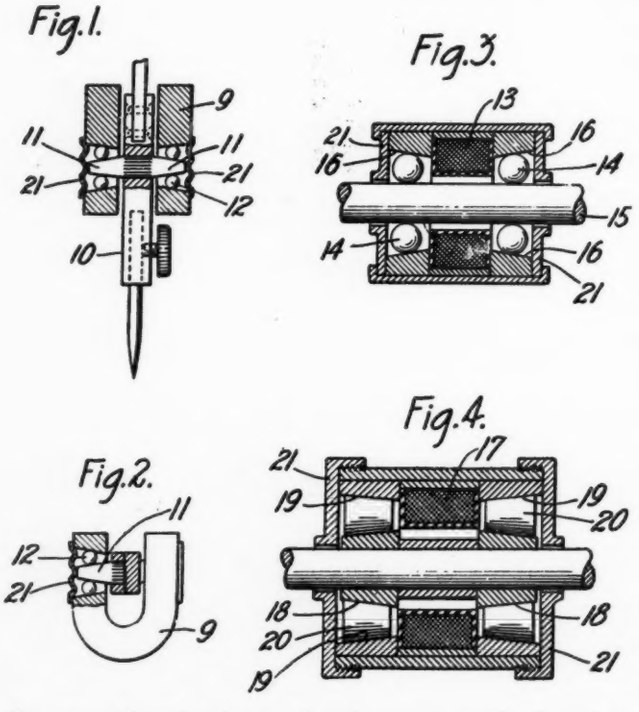

*Sectional views showing jointed push-rod and housing*

ture of the cylinder rises and the resultant expansion causes the projections 17 and 27 to separate. In the conventional engine this would result in increased clearance between the rocker arm and the valve stem. However, in the case of the newly designed mechanism the inventor declares that the push-rod housing members must follow their terminal supports and there assume a new position as indicated by the dotted line 50. This movement tends to align the push-rod members and maintains the clearance between the rocker arm and the valve stem regardless of the expansion or contraction of the various parts.

In Fig. 2, which shows a modification of the push-rod and housing joint, the housing member 19 is fixedly secured to the member 50, while the housing member 26 is provided with a flanged end 58, held in position by a gland 57, and so arranged as to permit a limited play between the members 26 and 50 and to take care of the change in angularity of the housings due to differential expansion.

A patent relating to bearings for rotating or oscillating members and particularly to such bearings which use balls, rollers, etc. between inner and outer races, has been granted to Henry C. Harrison, Port Washington, New York. It has been assigned to Bell Telephone Laboratories Inc., New York, and the number is 1,730,424.

The invention provides a bearing in which the intermediate bearing members are held in contact with both races so that each intermediate member will assume its share of the bearing load. This is accomplished by positioning a source of magneto-motive force, the magnetic circuit of which includes the intermediate members, which may be balls or rollers. At least one of the races is tapered so that the balls or rollers are constantly held in contact with both of the races. The magnetic circuit may be established by a permanent magnet or by an electromagnet.




*Cross-sectional views showing magnetic bearing applications*

### Shaft Is Conical in Shape

An application of the new invention is shown in Fig. 1 in the accompanying illustration, which is the stylus of a reproducer and has a conical shaped shaft extending out on either side. In Fig. 2 a permanent magnet is arranged with conical shaped openings of sufficient size to receive the shaft 11 and the balls 12. As the illustration shows, the shaft and balls are parts of the magnetic circuit.

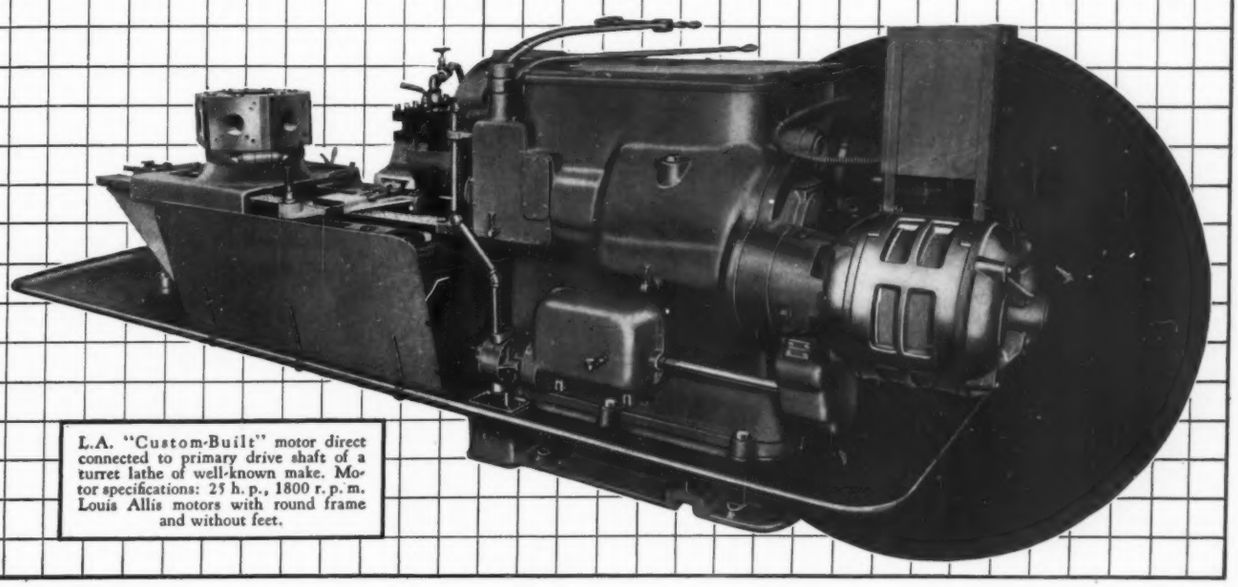
The balls are drawn into the narrower part of the space between the shaft and the permanent magnet by magnetic force. Since these balls will consequently contact with both surfaces, each ball will carry a portion of the load. Side motion of the stylus therefore will be materialy reduced and as the balls wear they will move toward the stylus, always keeping in contact with the surfaces and thereby prolonging the life of the stylus bearing. It is to be understood that the shaft 11 may be a permanent magnet and the magnetic circuit completed as desired.

Fig. 3 represents a bearing for a larger shaft, and since the magneto-motive force required in such a case is greater than normally can be supplied by a permanent magnet of suitable size, an electro magnet 13 having windings is used. In this case the balls have as the inner race the outer surface of the shaft. The outer race is at an angle to the axis of the shaft, and the magnetic circuit formed keeps the balls in contact. For bearings where it is desirable to use rollers an arrangement such as shown in Fig. 4 is employed.

Improvement in the construction of driving wheels of locomotives to overcome the difficulty encountered when using large axles and crankpins, where the amount of metal left between the respective bores is not sufficient to insure a tight fit, is the object of Patent No. 1,733,035 granted to Samuel M. Vauclain, Rosemont, Pa.

Moreover, the inventor seeks to make the axle disk and wheel concentric with each other, insuring ease of machining and a more symmetrical stress in the parts. Fig. 1 in the illustration on page 56 is a view of a locomotive driving wheel designed according to the invention. Fig.

# STEPPING UP MACHINE EFFICIENCY WITH "Custom Built" Motors



L.A. "Custom-Built" motor direct connected to primary drive shaft of a turret lathe of well-known make. Motor specifications: 25 h. p., 1800 r. p. m. Louis Allis motors with round frame and without feet.

Machinery Builders are STEPPING UP MACHINE EFFICIENCY—eliminating unnecessary machine parts and needless friction—with Louis Allis "Custom-Built" motors, designed to operate as integral parts of the machines they drive. Consider, for example, the above lathe with L. A. motor attached direct to the primary drive shaft...

*. . . Advantages to the USER*

1. Work Not Interfered With, the motor being mounted off the lathe head.
2. More Light on Work—fewer shadows.
3. Clear View Over Machine.
4. Motor Accessible for Greasing.
5. Machine Easier to Clean.
6. Needless Friction Eliminated.
7. Saves Power — Saves Time.

*. . . Advantages to the MACHINE BUILDER*

1. Saves cost of gears, sprockets, chains, pulleys, idlers, belts, and mounting bracket.
2. Eliminates need of securing motor dimension prints for each machine.
3. Saves Assembly Cost.
4. Makes Machine More SALEABLE.

*To Step Up Machine Efficiency—Specify L.A. "Custom-Built" Motors*

*Prompt Deliveries* Send for bulletins on L.A. "Custom-Built" Motors *Nationwide Service*

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"CUSTOM-BUILT" *Electric* MOTORS

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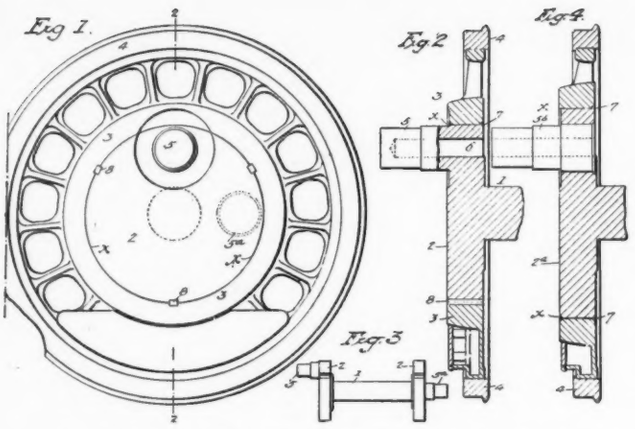
*Motor Specialists for 28 Years* / *Offices in Principal Cities*




*Newly designed locomotive driving wheel*

2 is a sectional view on the center line 2—2 in Fig. 1. Fig. 3 is a detached side view of the axle and integral disks and Fig. 4 shows a modification of the invention.

The disks 2 are made integral with the axle 1 in Fig. 3 and are turned concentric to the axle. Each disk fits the bore of the wheel center 3 in Fig. 1, which bore is concentric with its circumference and with the tire. Crank pins 5 and 5a, Fig. 3, are spaced at 90 degrees from each other and are shown integral with the disks 2, Fig. 2. The crank pins may be spaced at any other number of degrees than 90, for instance at 120 degrees for 3-cylinder engines. Each disk has an annular flange 7 at the inner side fitting a recess in the wheel center. Fig. 4 illustrating a modification of the invention, shows the crank pin 5b made as a separate member from the disk 2a and pressed into the crank pin opening, afterwards being riveted over as in the usual practice.

### Review of Noteworthy Patents

Other patents pertaining to design are briefly described as follows:

ROLLING MILL—1,729,696 for a method of operating a rolling mill. Assigned to United Engineering & Foundry Co., Pittsburgh.

BEARING—1,729,734, for a bearing for a gyroscopic compass embracing "a rotor, a support therefor, a ring in which said support is journaled, means for anchoring said support to said ring at one side. said support being freely movable relative to said ring at the opposite side." Assigned to Sperry Gyroscopic Co. Inc., New York.

CENTERLESS GRINDER—1,729,780, for a centerless grinding machine "comprising a rapidly rotated grinding wheel and a slowly rotated work regulating wheel, means of holding work of round section between said wheels, said means including a relatively fixed member and a relatively movable member, the latter being movable toward and away from said first mentioned member, and a mechanism constructed and arranged to move said second mentioned members to positions parallel to the work axis into contact with the work to hold the work between itself and said other member during grinding and away from the ground work to permit discharge thereof." Assigned to Cincinnati Grinder Inc., Cincinnati.

SAFETY STOP—1,730,188, for a safety stop to be used on "traveling structures movable along a trackway, comprising a wheel blocking member engageable between a wheel and rail, a rail clamp associated with said blocking member, and means for applying a thrust to said member sufficient to shift the same out of wheel blocking position when the said member is free of the wheel, and for maintaining said thrust if said member be held between the wheel and the rail to automatically shift the member out of rail engaging position when the blocking member is released by a movement of the wheel." Assigned to Wellman-Seaver-Morgan Co., Cleveland.

NUT MACHINE—1,730,483, for nut manufacturing by means of a combination of finishing mechanism including a finishing die, a punch for forcing nut blanks therethrough, a roller die in alignment with said finishing die and a tube for conveying blanks forced through said finishing die to said roller die under impulse of said punch. Assigned to Pittsburgh Screw & Bolt Corp., Pittsburgh.

ADJUSTING APPARATUS—1,730,640, for rolling mills, "consisting of a combination of a number of columns, a roll-carrying head slidably supported thereby, a plurality of simultaneously adjustable abutments, one associated with each of said columns and coacting with the upper portion of said head, means for simultaneously adjusting said abutments along the columns at uniform speed, and a plurality of quick-acting pressure elements, one associated with each of column, said pressure elements being adapted to be simultaneously actuated to force the head against and hold it against said abutments." Assigned to Budd Wheel Co., Philadelphia.

AUTOMATIC STOP—1,730,806, "The combination with a movable jaw, resilient means for moving the jaw in one direction and means for positively moving the jaw in the opposite direction, of a latch, means intermittently actuated by the movement of the jaw for supporting the latch in active position, a member movable synchronously with the jaw, and means for releasing the latch into the path of said member when the movement of the jaw in one direction is stopped at any point." Assigned to National Machinery Co., Tiffin, O.

METAL-SPINNING APPARATUS—1,728,002, for an "aparatus for roller spinning a sheet or metal strip pulley." Assigned to the Spun Steel Corp., Canton, O.

LATHE CROSS FEED—1,728,220, for a lathe cross feed. Assigned to the R. K. LeBlond Machine Tool Co., Cincinnati.

HOIST—1,729,262, for "a hoist, the combination of a frame, a hollow lift wheel within the frame, a bearing between the interior of the lift wheel and the frame adjacent one side of the lift wheel and a bearing between the exterior of a tubular extension on the lift wheel, a drive shaft extending freely through the lift wheel and having bearings on each side thereof in the same frame, and connecting mechanism between the drive shaft and the lift wheel." Assigned to Chisholm-Moore Hoist Corp., Buffalo.

SAND MACHINE—1,729,361, for apparatus for preparing molding sand. Assigned to Royer Foundry & Machine Co., Wilkes-Barre, Pa.

CAPPING MACHINE—1,729,454, for the purpose of applying caps to a group of containers. Assigned to Anchor Cap & Closure Corp., Long Island City, N. Y.

INSERTING ATTACHMENT—1,729,457, for an insert-

ing attachment for wrapping machines. Assigned by the inventor to American Machine & Foundry Co., Jersey City, N. J.

TRIMMER MECHANISM—1,720,460, for a trimmer mechanism for abrasive wheels. Assigned to Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

BEARING—1,730,896, for a shaft bearing embodying "a conical roller bearing having a race adapted to be forced into engagement with the interposed conical rollers, a warped spring ring acting upon said race at a plurality of points angularly spaced from each other end to end to force it into engagement with the rollers of said bearing, and an angular lug extending through said ring and adapted to form a guide for the same and to limit the motion of said race towards said ring for the purpose described." Assigned to Howell Electric Motors Co., Howell, Mich.

INDUSTRIAL CLUTCH—1,731,064, for construction of an industrial clutch having "a combination of a shaft, an inner clutch drum having a hub mounted on the shaft and rotatable therewith, an axially shiftable outer drum enclosing the inner drum, and interleaved disks between the drums, a brake member having a hub surrounding the shaft and having a bearing thereon, the outer drum having a hub mounted on the hub of the brake member, a motion transmitting wheel mounted in the hub of the outer drum, all whereby the brake member, wheel and outer drum are a movement, and a shifting fork interposed between the end of the hub of the outer drum and the brake member." Assigned to Brown-Lipe Gear Co., Syracuse, N. Y.

CUTOFF MECHANISM—1,731,355, for a cutoff device on a metal-working machine wherein stock is fed into the unit and cut into sections. Assigned to Roy H. Smith, Kent, O.

CHAMFERING ATTACHMENT—1,731,441, for an attachment to perform chamfering on a chaplet making machine "comprising a means for intermittently feeding a sheet metal strip along the bed, a reciprocating riveting head movable toward and from the bed for attaching wire stems to the strip at regularly spaced intervals along the length thereof, a reciprocating cutter spaced from the riveting head and operating in timed relation with respect thereto, for servicing the strip between successive stems, a rotary chamfering tool movably mounted between the riveting head and cutter, means operating in timed relation with respect to the movements of the head and cutter for shifting said tool into engagement with a stem, and means for driving said tool." Assigned to Fanner Mfg. Co., Cleveland.

MEASURING MACHINE—1,731,403, for a unit with means for moving material to be measured and a motor for operating. Incorporated in the design is a measuring roll disposed to be operated by the material to be measured, a metering device, a clutch for operatively connecting the metering device, and the measuring roll, and means disposed to be operated by the metering device upon the completion of a predetermined measurement to stop the motor. Assigned to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MOLDING WHEEL HUBS—1,731,445, for a "method of producing a hub having an exteriorly threaded collar at one end, said method consisting of forming said collar with an interiorly tapered surface, providing a mold conforming to said hub and with a recess for said collar, placing the collar in said recess, placing a core in said mold extending through said collar leaving a space between said core and collar, and filling said mold and space with molten metal." Assigned to Deere & Co., Moline, Ill.

DRIVING BELT—1,731,827, for a "drive belt formed of a plurality of links, each link comprising a flat plate having a plurality of extended loop interdigitating fingers, the ends of said loops being flattened, cross bars comprising upper and lower sections having inclined friction end faces, means of clamping the upper and lower sections of the cross bars together upon opposite sides of said plates, and pairs of rocker pins passing through the loops of the adjacent interdigitating fingers, each having a flattened side bearing against the flattened ends of the loops, for connecting the links together." Assigned to Reeves Pulley Co., Columbus, Ind.

CONVEYING AND DISTRIBUTING MECHANISM—1,732,207, for a bucket and boom conveying and distributing device consisting of a "combination of a boom supported on a vertical pivot to permit it to swing horizontally, a plate member supported concentrically relative to the vertical pivot of the boom and free to move rotatively relative to the latter." Assigned to Chain Belt Co., Milwaukee.

# Calendar of Meetings

**Nov. 13-16—American Institute of Steel Construction.** Annual convention at Edgewater Gulf hotel, Biloxi, Miss. Charles F. Abbott, 200 Madison avenue, New York, is executive director.

**Nov. 19.—Foundry Equipment Manufacturers association.** Fall meeting in New York. H. W. Standart, Northern Engineering Works, Detroit, is president.

**Nov. 20-21—National Founders' association.** Thirty-third annual convention at Hotel Astor, New York. J. M. Taylor, 29 South LaSalle street, Chicago, is secretary.

**Dec. 2-6—American Society of Mechanical Engineers.** Annual meeting at Engineering Societies building, New York. Calvin W. Rice, 29 West Thirty-ninth street, New York, is secretary.

**Dec. 2-7—National Exposition of Power and Mechanical Engineering.** Grand Central Palace, New York. Charles F. Roth, Grand Central Palace, New York, is manager.

**Dec. 10-11—Malleable Iron Research Institute Inc.** Meeting at Hotel Cleveland, Cleveland Robert E. Belt, 2013 Union Trust building, Cleveland, is secretary.

**Dec.—Hydraulic society.** Meeting in New York, C. H. Rohrbach, 90 West street, New York, is secretary.

**Jan. 8, 1930—Mining and Metallurgical Society of America.** Meeting in New York. Percy E. Barbour, 2 Rector street, New York, is secretary.

**Feb. 4, 1930—American Boiler Manufacturers association.** Semiannual meeting in Cleveland. A. C. Baker, 801 Rockefeller building, Cleveland, is secretary.

**Feb. 7-8, 1930—American Society for Steel Treating.** Semiannual meeting at Hotel Pennsylvania, New York. W. H. Eisenman, 7016 Euclid avenue, Cleveland, is secretary.

# Assets to the Bookcase

*Review of Books Pertaining to Design*

### A Comprehensive Study of Metals

*Principles of Metallurgy of Ferrous Metals*, by Leon Cammen; cloth, 202 pages, 6 x 9 inches, published by the American Society of Mechanical Engineers, New York, and supplied by *Machine Design* for $2.50 plus 15 cents postage.

Metallurgy is entering more and more into the field of machine design. No longer is it confined strictly to the metallurgist. The special alloys now used have made the microscopic study of metals an essential part of general engineering practice and as a consequence chief engineers and designers need comprehensive information on this subject to enable them to deal with problems involving metals and their application.

*Principles of Metallurgy of Ferrous Metals* has been written especially to fill this definite need. In it the author gives a concise summary of present theories and hypothesis. He shows the designer how to take advantage of the latest advances in the treatment of materials and, further, gives a comprehensive bibliography for reference.

While the subject is not an easy one to treat in a popular manner, involving as it does some of the later concepts of matter, some physical chemistry, and many new ideas associated with the heat treatment of metals, Mr. Cammen's book is written from a practical angle. As he says in one of the introductory paragraphs to Chapter 1, "A piece of steel in many respects resembles one who examines it. Like him it has properties which are determined by the materials of which it is composed, by the treatment it has received—its life history, by forces that act invisibly within it, and finally, by its environment. It will be the purpose of this book to discuss briefly all of those influences which contribute to make a piece of steel what it is, to the satisfaction or dissatisfaction of its users."

During the past few years much new evidence has been brought to light regarding the crystalline structure of metals, and some of the older theories necessarily have been discarded in view of these more recent research discoveries. Mr. Cammen, in the second chapter of his book, deals fully with the subject of crystalline structure of ferrous metals and shows how repeated alternating stresses cause weakness by affecting this structure, though not by causing what formerly was known as crystallization.

Properties of metals are dealt with in Chapter III. Knowledge of the methods of determining these properties is helpful to the designer, who undoubtedly will be able to apply much of the information given, in his choice of materials.

Informative chapters on heat treating, alloy steels and cast irons are included in the book, and steels and cast irons are included, and forgings and castings are covered fully in the concluding portion. The book is well printed on high quality paper, and contains 45 illustrations.

* * *

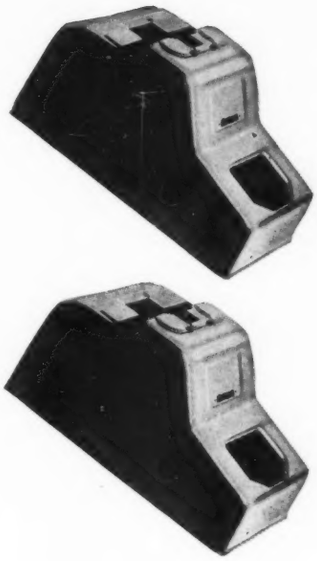
### Steel Under Heat Stress

*Creep of Steel at High Temperatures*, by F. H. Norton; cloth, 90 pages, 6 x 9 inches; published by McGraw Hill Book Co. Inc., New York, and supplied by *Machine Design* for $3 plus 15 cents postage.

This investigation of the creep resistance of steels was undertaken at the request of the Babcock & Wilcox Co., to provide engineering data at the higher temperatures. The work was carried on in the department of physics at the Massachusetts Institute of Technology. The author explains that difficulties in the path of accurately determining creep resistance are evidenced by the wide diversity of values obtained by different experimenters, and that there is much to be done in the development of research apparatus.

The flow occurring in steel is not certain, even after the subject has been studied by scores of experimenters. Further fundamental research is necessary. However, in the meantime designers require data on a large variety of steels for high temperature use, and the purpose of the book is to attempt to supply this data for a considerable number of materials at the higher temperatures.

Details of the problem and its solution, with descriptions of the testing devices, give an insight into what was sought and what has been accomplished up to this time. Descriptions of the steels tested are accompanied by microphotographs showing the structure of the metals.



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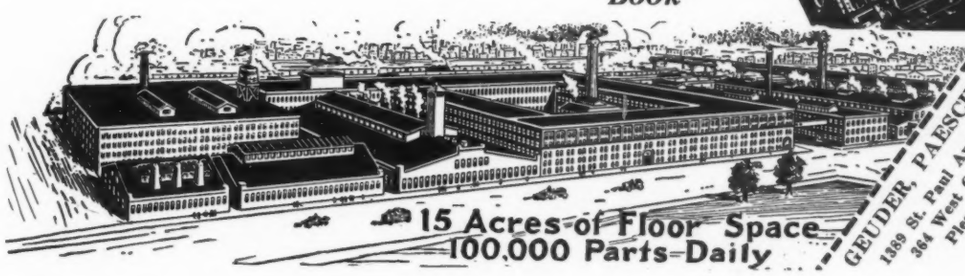


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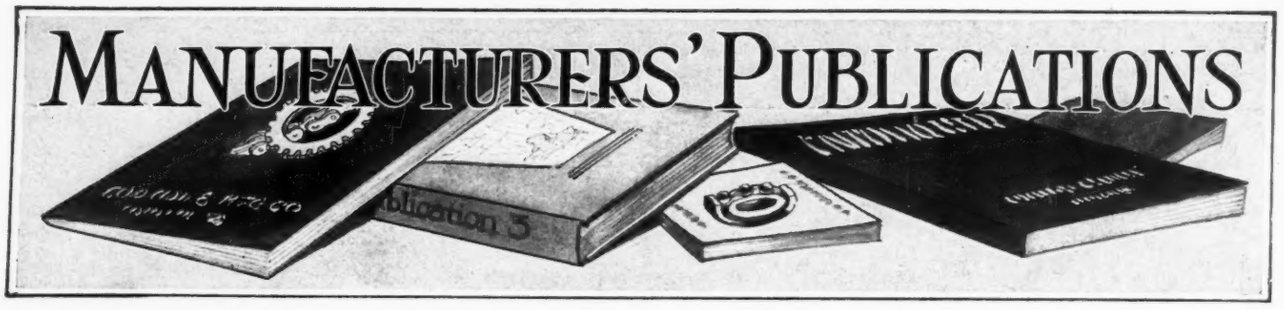

SPECIAL STEELS—A booklet recently issued by the Central Alloy Steel Corp., Massillon, O., Ludlum Steel Co., Watervliet, N. Y. and the Babcock & Wilcox Tube Co., New York, gives information on Enduro KA2 Steel, which is produced under Krupp-Nirosta patents. Enduro KA2 is described as an alloy of chromium, nickel and iron. When polished it is proof against water, atmospheric attack, dilute solutions and acids at high temperatures and high pressures. It takes and holds a mirror finish which is untarnishable under atmospheric conditions. It is described as being stronger than carbon steel, is easily workable and can be deep drawn, wire drawn, spun, machined and welded. The booklet illustrates application of Enduro KA2 in bank vaults, fireplace mantles, cooking utensils, chemical industry, tableware and numerous other uses. Data on its resistance to chemical attack are presented.

PSYCHROMETERS—Bristol Co., Waterbury, Conn., has issued a new catalog of its recording psychrometer, superseding previous issues. Illustrations and charts show its results and the degree of control obtainable from its use.

MOTORS AND GENERATORS—Century Electric Co., St. Louis, and Roth Bros. & Co., Chicago, one of its divisions, have issued bulletins on polyphase motors and motor generator sets, respectively. They are loose leaf for insertion in the general catalog. Illustrations and text cover the devices.

WIRE CLOTH—A bulletin on wire cloth in a wide variety of mesh and material has been issued by the Newark Wire Cloth Co., Newark, N. J. It shows typical examples of wire cloth in various meshes, and gives late information on gasketed metallic filter cloth leaf for flush plate and frame filter presses. A table of specific gravity and melting points of various metals concludes the booklet.

INGOT IRON—An outline of the fight against corrosion in the oil industry and results obtained by the use of pure iron in that field is given in a current booklet issued by the American Rolling Mill Co., Middletown, O. Ample data and illustrations cover the subject thoroughly.

STEAM TRAPS—Theory and the underlying principle of its steam traps are described in a booklet recently issued by W. B. Connor Co. Inc., 369 Lexington avenue, New York. Tables of sizes, capacities and dimensions of various type traps are included.

POWER TRANSMISSION—Dayton Rubber Mfg. Co., Dayton, O., gives a complete list of its Dayton cog-belt drives in its catalog No. 102 recently issued. The first of the eight sections into which the publication is divided, contains a description of the V-belt type of drive. Other sections cover illustrations of cog-belt drives, standard stock drives ranging from 2 to 25 horsepower, standard stock drives from 10 to 100 horsepower, nonstock drives from 50 to 100 horsepower, nonstock drives from 100 to 300 horsepower, prices on special nonstock drives, and special pulley features. Different colored paper for each section provides ready reference.

FLEXIBLE COUPLINGS—Valves and advantages of flexible couplings to connect machine units are discussed in a booklet published by the Poole Engineering & Machine Co., Baltimore. Sectional views and diagrams show construction and application of the company's couplings. Illustrations show typical installations. Specifications and dimension tables cover types applicable to various purposes.

VALVES AND FITTINGS—Reading Steel Castings Co. Inc., Bridgeport, Conn., in a current catalog covers the Reading-Pratt & Cady line of iron and bronze valves, asbestos-packed cocks and cast steel valves and fittings. It contains information on the care and use of valves, floor stand and chain wheel applications, drilling tables for iron, bronze, and steel flanges, and general information for the engineer.

LOCK-WASHERS—A circular showing various applications of Shakeproof lock-washers has been issued by the Shakeproof Lock Washer Co., 2501 North Keeler avenue, Chicago. Radios, switch terminals, outlet boxes, etc. are some of the applications described.

LUBRICATING SYSTEMS—Positive centralized lubrication is the text of a 16-page booklet issued by Lubrication Devices Inc., 50 South Washington St., Battle Creek, Mich., to describe the automatic Farval lubricating system manufactured by this company. Illustrations show the use of the system on large toggle presses, rotary newspaper presses, milling machines, a crane trolley and lathe. The booklet is entitled "A Picture Story of Farvel." This system consists of a compressor, reservoir, gage, a single main pipe line and an automatic valve at each bearing.

CONDUIT—Discussion of the advantages and typical installations of its electrical conduit are contained in a booklet distributed by the Youngstown Sheet & Tube Co., Youngstown, O. Engineering data, diagrams of various systems and illustrations are given.

MOTORS—Bulletin 508 containing 12 pages and recently issued by Louis Allis Co., Milwaukee, describes and illustrates a line of explosion-proof self-ventilated squirrel-cage motors ranging in capacity from ¼ to 25 horsepower.

CHROME ALLOYS—A description and discussion of characteristics and adaptations of various corrosion resistant alloys, illustrating the uses to which they can be applied, comprise the contents of a booklet issued by Dowington Iron Works, Dowington, Pa.